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USAEPG-SIG 920-72

FINAL REPORT

OPERATIONAL EVALUATION OF ECM SET AN/MLQ-8(XL-2) ~~(U)~~

~~(PROJECT 33-56-0013)~~

EW SYSTEMS TEST
USAEPG-3
PHASE II
EQUIPMENT TEST
AND EVALUATION

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U.S. ARMY ELECTRONIC PROVING GROUND
FORT HUACHUCA, ARIZONA
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Page 58. Paragraph 1, 3d sentence "tactical" should read "tactile."

Page 59. Paragraph 4, add parenthesis at end of last sentence.

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FINAL REPORT
OPERATIONAL EVALUATION
OF
ECM SET AN/MLQ-8(XL-2) (U)
(Project 33-56-0013)

February 1957

Electronic Warfare Department
U. S. ARMY ELECTRONIC PROVING GROUND
Fort Huachuca, Arizona

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FOREWORD

This final report on the operational evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-2) is based on field tests using the set to jam VT-fuzed fire from 105-mm howitzers, 81-mm mortars, and 4.2-in. mortars. The tests were conducted as a part of Project 33-56-0013 (USAEPG-3 EW Systems Test) of the U. S. Army Electronic Proving Ground Technical Program during the periods June to July and September to November, 1956.

Support was furnished by C Battery, 294th FA Bn, Fort Bliss, Texas; C Battery, 38th FA Bn, Fort Lewis, Wash.; 2d Platoon, Heavy Mortar Co, 5th Inf Reg, Fort Lewis, Wash.; Flash Plt and Survey Plt, B Batt, 617th FA Obsn Bn, Fort Sill, Okla.; Flash Plt and Survey Sq, A Batt, 285th FA Obsn Bn, Fort Bragg, N.C.; U. S. Army Security Agency Operational Center, Fort Huachuca, Ariz.; and 1st Signal Group, USAEPG, Fort Huachuca, Ariz.

H. McD. BROWN
Col SigC
Chief, Electronic Warfare Department

ABSTRACT

The final operational evaluation report on Electronic Countermeasures Set AN/MLQ-8(XL-2) ~~is~~ is a swept repeater jammer designed to predetonate VT fuzes operating between 130 and 200 Mc/s~~. concludes that~~ when two equipments are paired they can protect 1.3 sq mi and attain a maximum effective range of 11,000 yards against 105-mm howitzer fire using T226E2/A fuzes.

The set is sufficiently staunch for most field applications. If the set is mounted in a 1/4-ton vehicle, the vehicle should have heavy-duty springs on the rear axle. Set-up and take-down times were found to be satisfactory. The AN/MLQ-8(XL-2) is not readily subject to electronic intercept and is very difficult to locate by direction finding ~~(D/F)~~ equipment. Reasonable concealment measures provide some protection from aerial observation, but the sound of the power unit will betray its presence to patrols.

Certain shortcomings are presented: interference between the jammer and its component communications radio; diminished range when fuzes in simultaneous flight share power; the need for an average of 5.45 sweeps to obtain predetonation; and insufficient capability in the lower frequencies needed to counter 155-mm and 8-in. howitzer fire. Despite these limitations, the equipment is considered basically a usable jammer for tactical employment.

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Section I. Summary

The AN/MLQ-8(XL-2), a swept repeater jammer with superheterodyne circuitry and a single antenna, was designed to predetonate Doppler VT fuzes. The 3 Mc/s passband sweeps at a variable rate across the entire frequency band of 130-200 Mc/s. The equipment is mounted in a 1/4-ton truck and is provided with power from a unit towed in a trailer.

Tests were conducted to determine the area of effectiveness against high- and low-angle fire from 105-mm howitzers at aspect angles of 0, 45, and 90 degrees and against 4.2-in. mortars at 90-degree aspect. It was found that a pair of AN/MLQ-8(XL-2) sets will protect an area of approximately 1.3 sq mi from CVT fuzes arming 3 seconds before impact in concentrations of four or less simultaneously active fuzes. As the number of active fuzes is increased, the area protected will diminish because the emitted jamming power is shared by the fuzes. During a saturation test it was found, however, that the limitation caused by power-sharing was not as serious as had first been expected. As the number of active fuzes increases from one to four, the effective range decreases from 9,000 to 7,800 yards. The jammer averages 5.45 sweeps to effect predetonation.

Tests of susceptibility and vulnerability demonstrated that the equipment was very difficult to locate by D/F equipment. When reasonable measures were taken for concealment from visual observation, the equipment proved extremely difficult to locate by patrols at night or by daylight aerial observation. Aural detection is possible at greater distances than visual detection because the power unit is noisy. Communications are prevented during jamming because the equipment interferes with its own component, Radio Set AN/VRC-17.

The maximum effective range of the AN/MLQ-8(XL-2) is 11,000 yards, but with parameters most likely to be available during actual combat, the maximum range lies between 3,800 and 4,500 yards. One factor affecting range is the need for correct siting. The jammer cannot protect itself, but must be used as one of a pair affording mutual protection. The jammer obtained a kill of 90 percent at about 6,000 yards against the 4.2-in. mortar, but its effectiveness against the 81-mm mortar was 60 percent or less.

Section II. Introduction

1. BACKGROUND

Electronic Countermeasures Set AN/MLQ-8(XL-2) is an outgrowth of Radio Repeater Set AN/MLQ-8(XL-1), which was first produced as an experimental VT-fuze jammer by the University of Michigan in 1954. The AN/MLQ-8(XL-1) is a single-antenna, superheterodyne, swept repeater jammer with a power output of approximately 100 watts. Four prototype models of the AN/MLQ-8(XL-1) fabricated by the Electronic Defense Laboratory (EDL) were tested at the U. S. Army Electronic Proving Ground (USAEPG) in 1955. Results were encouraging, and two models of a miniaturized and ruggedized version, mounted in a 1/4-ton truck and designated the AN/MLQ-8(XL-2), were delivered for testing at USAEPG in March 1956.

The AN/MLQ-8(XL-2) model differs from its prototype in some respects other than size and weight. The frequency range of the AN/MLQ-8(XL-2) is 130 to 200 Mc/s, whereas the AN/MLQ-8(XL-1) model had a range of 110 to 170 Mc/s. The instantaneous bandwidth is 3 Mc/s compared to 12 Mc/s for the earlier jammer. A squelch control provided in the AN/MLQ-8(XL-2) reduced the possibility of ground returns causing loop feedback; the AN/MLQ-8(XL-1) model did not possess this circuitry. The mixer of the AN/MLQ-8(XL-2) recovery time was only one-tenth as fast as that of its predecessor.

2. PURPOSE

The purpose of the test is to determine the degree to which the AN/MLQ-8(XL-2) would serve the original purpose of the earlier AN/MLQ-8(XL-1), to jam proximity fuzes in defense of an area, and to develop doctrine for use of the equipment.

Preliminary tests showed that performance of the AN/MLQ-8(XL-2) was far below that obtained from the AN/MLQ-8(XL-1). Various engineering changes were made by the manufacturer, including correction of the unduly slow recovery time of the input mixer. The performance then improved to a point where the equipment gave promise of being tactically acceptable. Other elements of the original equipment which were modified included the plate dropping resistors, the if. bias resistors, the gate generator circuit, and the indicator. The power if. plate dropping resistors were found to be near the critical wattage rating. These resistors burned out during use and were replaced with elements of higher power rating. This field modification has now been incorporated in all the AN/MLQ-8(XL-2) sets. Power if. bias resistors were added to the first three stages to change the bias from zero to a low

value. The gate generator has been modified to eliminate spurious vhf oscillations in the vicinity of 400 Mc/s on all AN/MLQ-8(XL-2) models. Indicator operation has been modified to present an instantaneous presentation instead of the former presentation delayed for a period of 2 or 3 usec, and the high-voltage rectifier in the indicator was modified to eliminate voltage breakdown.

3. SCOPE

This final evaluation report describes tests to determine facility of operation, vulnerability, range, effectiveness, and such operational requirements as long-time maintenance problems and man-machine compatibility. The conclusions, in general favorable, also point out (1) limitations of the set due to power-sharing among simultaneous projectiles, (2) minor modifications which would improve effectiveness, and (3) principles of tactical doctrine that the tests have made evident.

Section III. Description of Equipment

4. PHYSICAL DESCRIPTION

The AN/MLQ-8(XL-2) is a swept repeater superheterodyne countermeasures set intended to predetonate proximity-fuzed projectiles and missiles. The passband of the set is swept periodically over the entire frequency band of 130-200 Mc/s by automatically varying the frequency of the local oscillator.

The AN/MLQ-8(XL-2) and a radio communication set are mounted in a 1/4-ton vehicle. The PU-104 power unit for the jammer is mounted in a 1/4-ton trailer towed by the vehicle. The trailer also carries spare parts for the jammer, the power cabling, and the antenna when not in use.

The antenna is a folded dipole with a corner reflector. It can be operated from a mast socket-mounted on the jeep, providing 10 feet of elevation, or on a tripod, providing 5 feet of elevation. The antenna is adjustable in azimuth and polarization, and the elevation angle is set by rotating a pivoted arm approximately 42-1/2 inches long. The set is shown in fig. 1.

5. TECHNICAL CHARACTERISTICS

a.	Frequency of operation:	130-200 Mc/s with provision for restriction of operation to a portion of this band
b.	Average power output:	75 watts (minimum) over the entire band
c.	Sweep rate of local oscillator:	1 to 3 sweeps/sec
d.	Duty cycle:	Adjustable from 1/2.5 to 1/5.5
e.	Delay Time:	2 usec
f.	Pulse length:	2 usec
g.	IF. center frequency:	111 Mc/s
h.	IF. bandwidth:	9 Mc/s at 1-db points; 12 Mc/s at 3-db points
i.	System bandwidth:	3 Mc/s at 3-db points

Fig. 1. Electronic Countermeasures Set AN/MLQ-8(XL-2)

j. Squelch: Squelch circuit suppresses radiation when input signals are below a designated power level. The circuit is adjustable and may be disabled. The squelch circuit can be adjusted from 11 to 50 uv and may be made to repeat for periods up to 30 ms.

k. Power requirements: 110 volts, 3 phase, 400 cps.

6. OPERATION

Since the transmitter operates only as a repeater, the system functions as a search receiver until a signal which is within its passband is received. When such a signal is intercepted, it is mixed with the output of the local oscillator to obtain the desired intermediate frequency. The signal is passed through the if. amplifier stages, delayed for 2 usec, then gated into the power mixer stage. There, it is mixed with the output of the local oscillator which, during the delay time, has been swept to a higher frequency. The VT-fuze signal from the power mixer is amplified and transmitted as a jamming signal.

Since the output of the local oscillator, common to both the receiver and transmitter, is swept at a certain rate and the input signals are "stored" in a 2-usec delay line before retransmitting, the transmitter's output signal presents to the fuze a frequency shifted from that of the receiver input. Not counting the space or true Doppler effect, the fuze receives a signal a few hundred cycles different in frequency from the one it transmitted to the jammer. This signal "looks" the same to the fuze receiver as one it would receive when approaching a target, and the fuze predetonates when the necessary intensity of signal is achieved.

Section IV. Tests to Determine Facility of Operation

7. TEST 1. RUGGEDNESS OF AN/MLQ-8(XL-2) AND VEHICLE

The purpose of test 1 was to determine the ruggedness of the AN/MLQ-8(XL-2) and vehicle. At the time of the tests the installation of the AN/MLQ-8(XL-2) in the M38A1 vehicle had been completed with the exception of providing heavy duty springs on the rear axle. Since such springs were not available, a comprehensive test of ruggedness could not be performed without fear of damaging the vehicle. Throughout the tests the electrical equipment suffered no malfunction as a result of the field work. One antenna mast was broken when the equipment was being moved over a rough road with the antenna erect. The AN/MLQ-8(XL-2) appears to be sufficiently rugged for most field applications if proper care is taken to store the antenna and mast in their proper places prior to transportation. It is recognized that heavy duty springs must be installed on the vehicle before the set can be termed tactically rugged. When this is done, the transportability of the set will be equivalent to that of a heavily loaded 1/4-ton truck and associated trailer.

8. TEST 2. SET-UP AND TAKE-DOWN TIMES

The purpose of test 2 was to determine the set-up and take-down times. Only experienced operators and EDL-trained NCO's were used in these tests. In every trial the NCO briefed the driver-operator on his duties which resulted in very little wasted time.

The only important delay in set-up time is warming the power unit. The results shown apply to a unit previously warmed up. If a power unit is cold, 1-15 minutes are required to start the engine.

To determine set-up time, the stopwatch was started with both operators still seated in the vehicle and was stopped when the NCO announced that the equipment was in operation. All antenna adjustments were made using a compass and spirit level. Times recorded for tripod-mounted antennas do not include the necessary time to drive the ground stakes. The antenna azimuth, elevation, and polarization were different for each trial. The results are as follows:

Arrangement of equipment	Trial (nr)	Setup (min)	Secure (min)
Antenna mounted on tripod, power unit off and located 50 ft. away.	1	5.22	3.26
	2	5.92	6.07
	3	5.30	4.75
Antenna mounted on 1/4-ton truck, power unit off and located 50 ft. away.	1	5.18	4.93
	2	5.60	4.00
	3	5.02	3.40
Antenna mounted on 1/4-ton truck, power unit off and hitched to 1/4-ton truck.	1	4.37	1.93
	2	4.29	1.84
	3	3.98	2.38
Same as above except power unit in operation.	1	3.13	1.81

9. TEST 3. CIRCUIT STABILITY

The purpose of test 3 was to determine the effect of line voltage on power output.

The equipment was set up so that the line voltage and the power output could be measured. Fig. 2, which shows the results obtained, indicates that a decrease of 12 percent in line voltage results in a corresponding 60-percent decrease in power output.

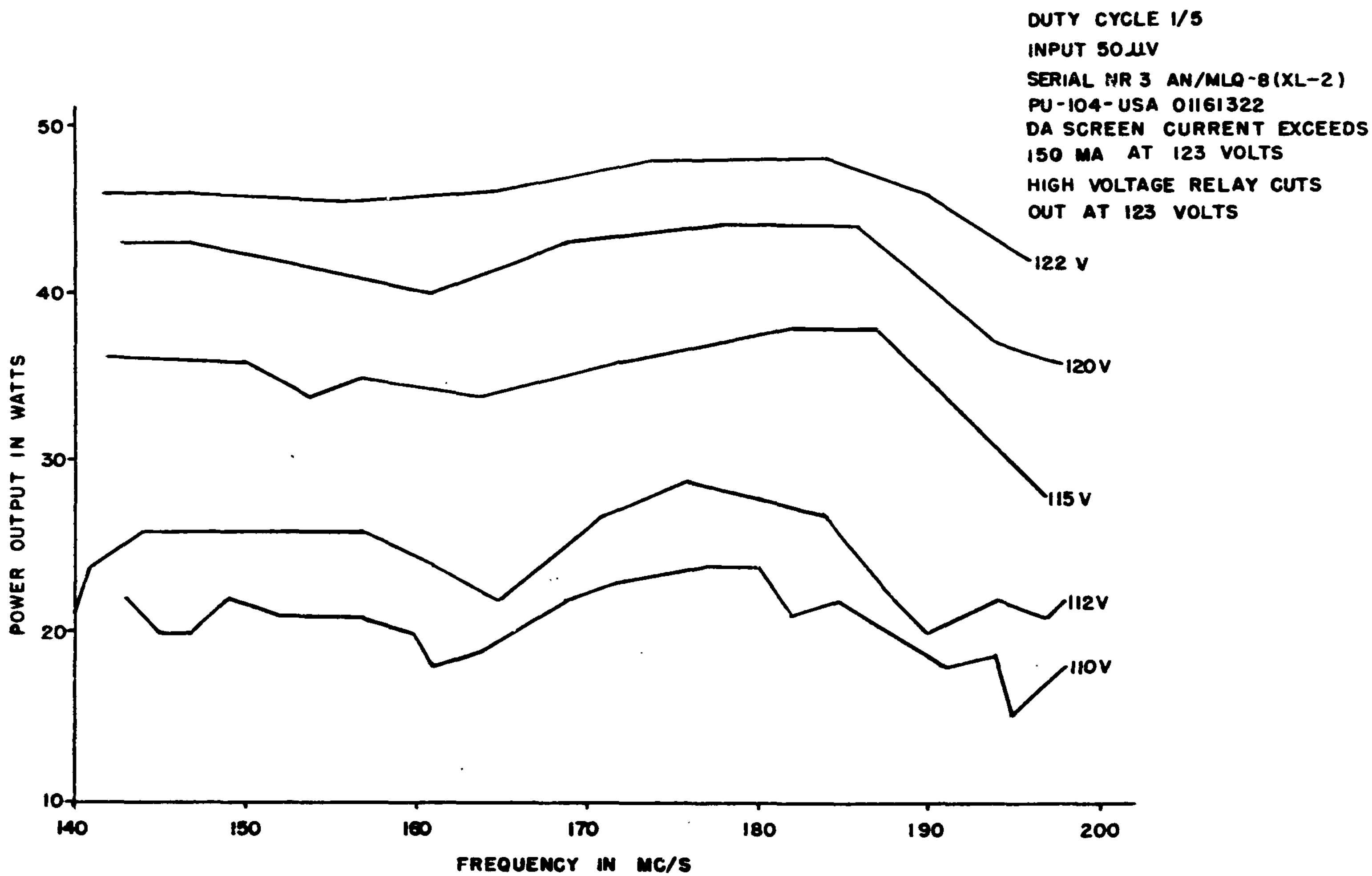


Fig. 2. Voltage curves with power unit under load

Section V. Susceptibility and Vulnerability to Enemy Action

10. TEST 4. NOISE RADIATION FROM THE AN/MLQ-8(XL-2)

The purpose of test 4 was to determine the noise radiation from the AN/MLQ-8(XL-2). The jammer was sited at ranges of 5,000, 10,000, 15,000, 30,000, and 60,000 yards from Countermeasures Receiving Set AN/TLR-9, which attempted to analyze the noise radiation of the jammer with and without its squelch circuit in operation and with its antenna pointed toward or away from the receiving set. When the jammer's squelch circuit was on, its signal was not discernible at any range regardless of the direction of its antenna. With the squelch circuit off, the signal was discernible at 5,000 and at 10,000 yards regardless of the direction of the jammer's beam, but at 15,000 and 30,000 yards, it could be detected only when the jammer was directed toward the receiver. At 60,000 yards, no signal was received. At no time was the second or third harmonic radiation apparent.

11. TEST 5. VULNERABILITY TO ELECTRONIC INTERCEPT AND D/F

The purpose of test 5 was to determine the accuracy with which the AN/MLQ-8(XL-2) could be located by D/F and its transmitted signal analyzed.

The AN/MLQ-8(XL-2) was sited 10,000 yards from an AN/TLR-1 intercept receiver and an AN/TRD-10 D/F set. The jammer was triggered locally with a signal generator to simulate VT fuzes. The AN/TLR-1 team was then told the approximate direction to point its antenna, and to monitor the correct frequency and measure the pulse duration and pulse repetition frequency.

It required 1.5 minutes to obtain the pulse duration of 1.75 microseconds (2.0 was correct) and 3.5 minutes to measure the pulse repetition frequency of 88 kc/s (100 kc/s was correct). At the same time, the D/F team was asked to measure the bearing of the AN/MLQ-8(XL-2). The signal received by the D/F set was very weak and the bearing was reported to be 56.5-degrees magnetic. The correct bearing was 80.5 degrees. The range was then reduced, from 10,000 to 3,700 yards, and another D/F trial was made. The reported bearing was 83.5-degrees magnetic whereas the correct bearing was 90.9 degrees.

For the above tests, the jammer antenna was pointed directly at the intercept and D/F site. When the jammer antenna was pointed 90 degrees away from the D/F site, the signal could not be detected.

To add more realism to the intercept and D/F operations, slow and rapid fire were simulated. The jammer was triggered for 15 seconds at 1- to 5-minute intervals to simulate slow fire, and at 15-seconds duration with a 10-second interval for rapid fire. Again the signal analysis (pulse duration only) and D/F operations were carried out. The results are shown in Table I.

Table I. Intercept and D/F Operations against AN/MLQ-8(XL-2)

Rate of fire	Trial (nr)	Frequency (Mc/s)	Pulse duration (usec)	Bearing reported (deg)	Remaining time for D/F (sec)
Slow fire	1	149	---	---	0
	2	144	---	---	0
	3	----	---	---	0
	4	146	2.0	---	10
	5	139	---	---	5
	6	144	---	---	0
	7	156	---	---	---*
	8	145	2.75	60	20
1- to 5-min intervals	9	145	2.75	60	10
	10	146	---	94	12
	11	156	---	---	6
	12	139	2.0	---	1
	13	149	---	---	0
	14	137	---	---	0
	15	136	2.75	---	2
Rapid fire	1	136	---	---	0
	2	148	1.75	---	0
	3	144	---	---	0
	4	142	----	55	5
	5	139	2.75	---	0
	6	144	---	---	0
	7	141	2.75	80	5
	8	138	2.0	---	0
10-sec interval	9	149	---	---	2
	10	148	---	82	6
	11	141	1.5	69	4
	12	138	---	---	7
	13	141	1.5	65	10
	14	135	double pulse	65	7
	15	141	1.25 to 1.5	---	6
Constants of the test: signal duration 15 sec; correct bearing 80.5 deg					

*AN/TLR-1 gave erroneous frequency; later corrected to 156 Mc/s.

12. TEST 6. VULNERABILITY TO DAYLIGHT OBSERVATION

The purpose of test 6 was to determine the vulnerability of the jammer to air reconnaissance. Photographs were taken at an altitude of 4,000 feet above ground when the equipment was sited in average desert terrain but left unconcealed (location A), in similar terrain but concealed (location B), and in open terrain with no attempt at concealment (location C). The following illustrations were reproduced from unretouched prints of one-half-by-one-inch portions of a KODAK AERO RECON negative enlarged 36 times to an area of three-by-six inches. Fig. 3 shows two photographs of location A; in view (a) the site is vacant, but in view (b) the equipment is sited without concealment. Fig. 4 shows similar views of location B; in view (a) the site is vacant, and in view (b) the equipment is concealed. Fig. 5 provides similar views of an open area; in view (a) the site is vacant, and in view (b) the equipment is in place. It is apparent that the equipment is difficult to perceive if it is properly concealed; but when it is in open ground, detection becomes a simple matter.

13. TEST 7. VULNERABILITY TO NIGHT OBSERVATION

The purpose of test 7 was to determine the vulnerability of the AN/MLQ-8(XL-2) to night observation. Two AN/MLQ-8(XL-2) equipments were taken into Fort Huachuca's West Artillery Range and sited in different surroundings. Equipment nr 1 was set up with the power trailer attached to the 1/4-ton truck and the antenna in its 1/4-ton truck mount, and the power unit was put into operation. The general surroundings were fairly open country; the equipment itself was in an open space with desert shrubbery in the background. One 15-foot yucca plant was about 15 yards behind the antenna, as shown in fig. 6. Equipment nr 2 was set in an area of scrub vegetation with the antenna ground-mounted on its tripod, the power unit and trailer detached and hidden in shrubbery, and the equipment itself concealed in shrubbery about 5 feet high.

The moon was bright, and although heavy clouds obscured it at times, there was much reflection from the broken clouds. Visibility was, therefore, very good. Sets of 6 x 30- and 7 x 50-mm binoculars and an infrared snooperscope, provided by Battle Area Surveillance Department, were used for the visual observation.* The results were as shown in the tabulation on the next page of the text.

---

* No series of observations of the distance at which the power unit is audible were made. However, it was determined that the power unit was heard loud and clear at a distance of 308 yards. It must, therefore, be considered as vulnerable to detection by aural detection means.

(a) Site vacant

(b) Equipment sited but not concealed

Fig. 3. Test 6, location A; average terrain; no concealment

(a) Site vacant

(b) Equipment sited and concealed

Fig. 4. Test 6, location B; average terrain; vacant and with concealed equipment

(a) Site vacant

(b) Equipment sited and in view

Fig. 5. Test 6, location C; open terrain; site vacant and with equipment

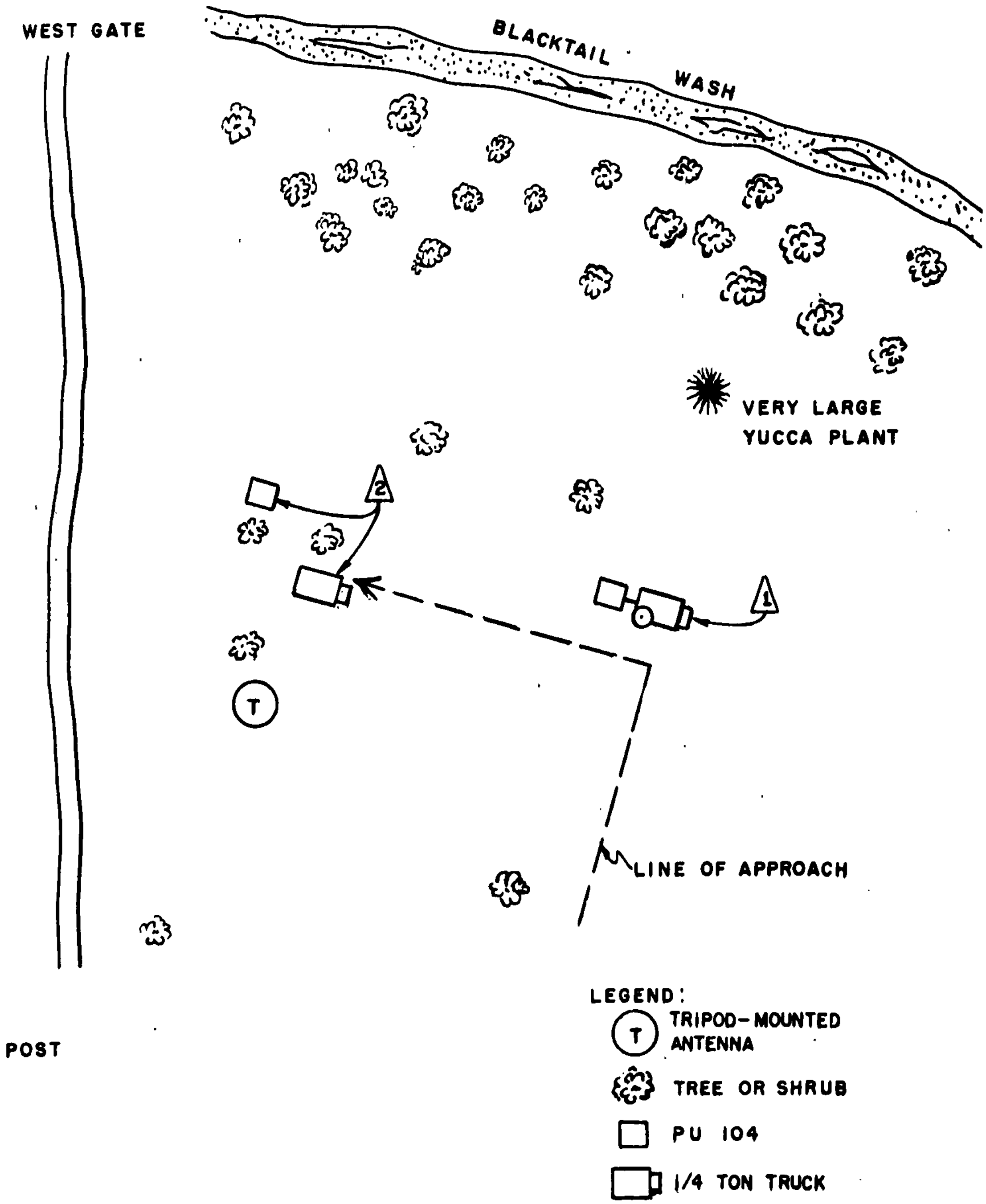


Fig. 6. Siting arrangement for night observation, test 7

Approaching equipment (nr)	Distance (yds)	Comment by observers
1	308	Power unit heard loud and clear
	220	Antenna visible through binoculars
	176	Antenna and personnel visible through binoculars
	88	Antenna visible with naked eye; jeep barely visible with infrared scope
2	132	1/4-ton truck windshield barely visible through binoculars
	88	1/4-ton truck visible with infrared scope and to naked eye

The tall yucca plant behind the antenna of equipment nr 1 made the antenna extremely difficult to see. If it were not for the power unit in operation, the antenna would probably not have been noticed even at 100 yards. Ordinary camouflage and choice of siting for concealment from observation present no problem, except that the power unit is vulnerable to aural detection.

14. TEST 8. INTERFERENCE BETWEEN THE AN/MLQ-8(XL-2) AND RADIO SET AN/VRC-17

The purpose of test 8 was to determine the effect of jamming operations on communications between the jammer teams.

a. Effect of Jammer on Radio Set

The AN/MLQ-8(XL-2) serial nr 1 was put into normal jamming operation. AN/MLQ-8(XL-2) serial nr 2 was sited at 5,000, 10,000, and 15,000 yards from serial nr 1 and communications reception tested. Three factors were varied separately; the squelch circuit of the operating jammer was turned on and off, the AN/VRC-17 antenna was alternately mounted in a 1/4-ton truck and a trailer, and the operating AN/MLQ-8(XL-2) was beamed directly upon the AN/VRC-17 and then turned 90 degrees away from the radio set.

With the antenna mounted in a 1/4-ton truck and the jammer antenna oriented 90 degrees to the AN/VRC-17, interference began at 10,000 yards. Moreover, with the jammer antenna pointed directly at the AN/VRC-17, at 10,000 yards no portion of the communication was understandable. When the antenna of the radio receiver was mounted on a trailer and the jammer antenna oriented at 90 degrees to the AN/VRC-17, interference was slight at 10,000 yards; whereas at 15,000 yards only occasional words were audible. When the jammer antenna was oriented 0 degrees from the AN/VRC-17, interference was heavy at 10,000 yards and complete at 15,000 yards.

Under the conditions specified above, when the squelch circuit is not in operation, interference occurs at communication ranges of 10,000 yards or more, when the squelch circuit is in operation, no interference occurs at ranges of 5,000 to 15,000 yards. The effect of a strong interfering signal from the jammer on the AN/VRC-17 is a burst of noise lasting approximately 1/2 second. When the jammer to radio range is 10,000 yards and a weaker signal is received the noise burst lasts for 3/4 of a second.

b. Effect of Radio on Jammer

Interference with the AN/MLQ-8(XL-2) occurs when the 5th, 6th, and 7th harmonics of the AN/VRC-17 transmitter frequency is repeated by the jammer. The 6th harmonic of 27.6 Mc/s falls in the center of the presently used fuze frequency band, and causes power sharing between the fuze signal and the harmonic. A complete check of the AN/VRC-17 revealed no abnormal condition. Therefore, the operator is prevented from sending or receiving signals while the AN/MLQ-8(XL-2) is in operation.

Section VI. Range and Effectiveness

15. TEST 9. EFFECT OF DUTY CYCLE UPON KILL

The purpose of test 9 was to determine the effect on percentage of kill by a change in duty cycle. Only 1/3 and 1/5 duty cycles were compared.

The jammer was positioned at 90-degree aspect so that with optimum conditions the jamming range was near the maximum effective range. A comparison was then made between the two duty cycles. This procedure was then repeated at a greater range of 1,000 yards. The results shown in fig. 7 indicate that a duty cycle of 1/5 is more effective than one of 1/3. The value of 1/5 was then chosen as the best duty cycle for average conditions and was used in all tests requiring the use of such conditions.*

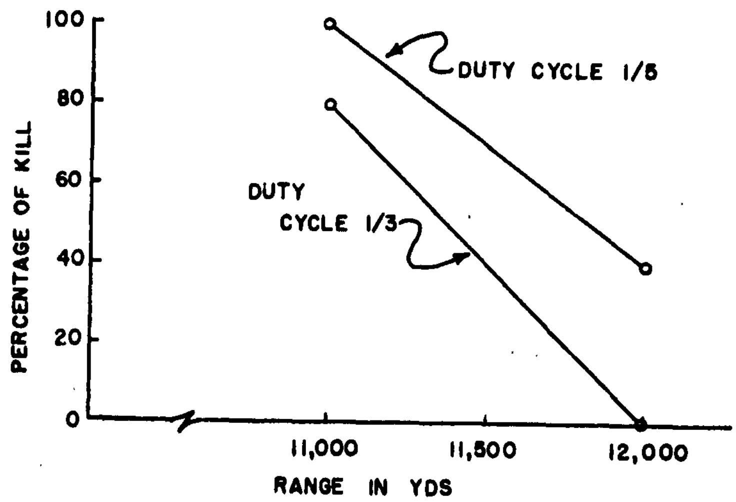


Fig. 7. Effect of duty cycle on percentage of kill

16. TEST 10. THE OPTIMUM SWEEP RATE FOR HIGH- and LOW-ANGLE FIRE FROM THE 105-MM HOWITZER

The purpose of test 10 was to determine (1) the effect of sweep rate upon percentage of kill and (2) the sweep rate that produces the

* See appendix A for a definition of average conditions.

best results against low-angle fire. The jammer was positioned at 90-degree aspect so that with optimum antenna parameters and the theoretical optimum sweep rate a kill of 50-80 percent was achieved. Every parameter was then held constant except the sweep rate, which was varied over a large range, and the change in percentage of kill was noted. Both high-angle fire with charge 3 and low-angle fire with charge 4 were used with a 105-mm howitzer firing at a range of 5,000 yards. With high-angle fire, three types of fuzes were used: T226/A, T226E2/A, and T226E2/C. Only the T226E2/A fuze was used with low-angle fire.

The data shown in fig. 8 shows (a) the results against the three types of fuzes at high-angle fire and (b) the results against the T226E2/A fuze at both high- and low-angle fire. Fig. 8(b) indicates that the optimum sweep rate for low-angle fire with the T226E2/A fuze is 2.0 sweeps/sec. This is considered of primary importance since artillery uses low-angle fire about 95 percent of the time during combat, and most of the tests were performed using this sweep rate against the T226E2/A fuze.

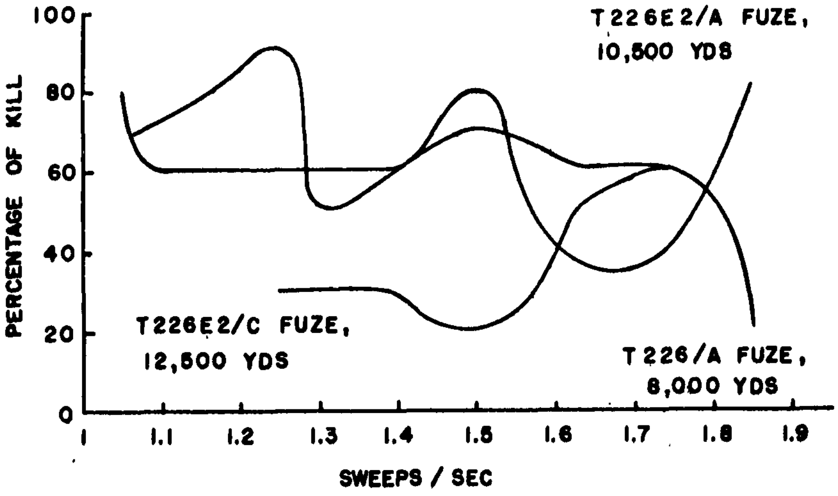
17. TEST 11. EFFECT OF SQUELCH-CIRCUIT OPERATION ON AN/MLQ-8(XL-2) JAMMING

The purpose of test 11 was to note any change in effectiveness during use of the squelch circuit, the purpose of which is to prevent transmission unless the received signals are above a certain level or strength.

The technical characteristics of the squelch circuit are as follows:

Squelch sensitivity	Input signal strength (uv)	Condition	Time squelch is energized (ms)
Max	17	Barely triggered	55
Max	25	Saturated	80
Min	23	Barely triggered	50
Min	30	Saturated	70

This test was run concurrently with a low-angle, maximum-range test; the only variable being squelch on or squelch off. Both of these results are plotted in fig. 9 which indicates inconsistent results, but it is evident that energizing the squelch circuit has little or no effect on maximum range when optimum conditions prevail. In the following descriptions of tests, "squelch on" means that the squelch circuit is energized with maximum sensitivity.



(a) Percentage of kill vs sweeps/sec, high-angle fire, three fuze types

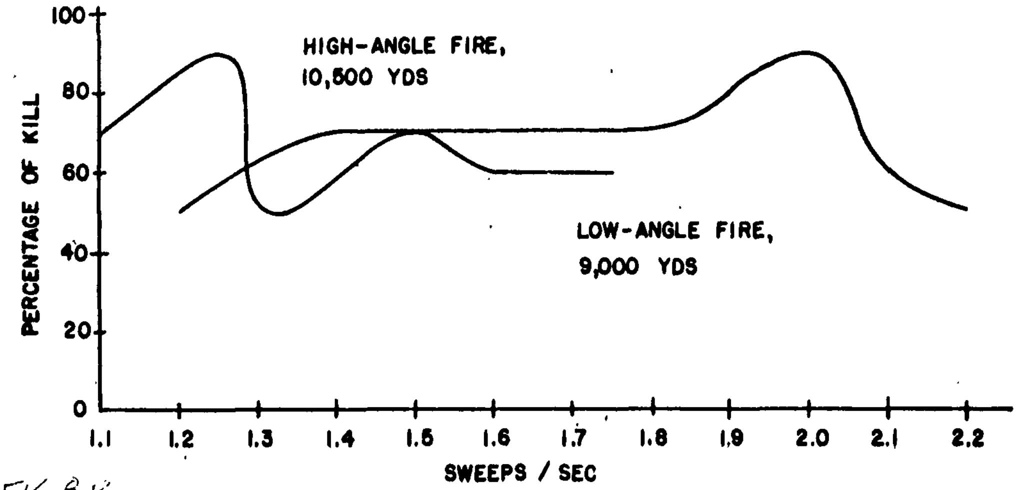


FIG 8 B

(b) Percentage of kill vs sweeps/sec, high- and low-angle fire, fuze T226E2/A

Fig. 8. Effect of sweep rate on percentage of kill, 105-mm howitzer fire

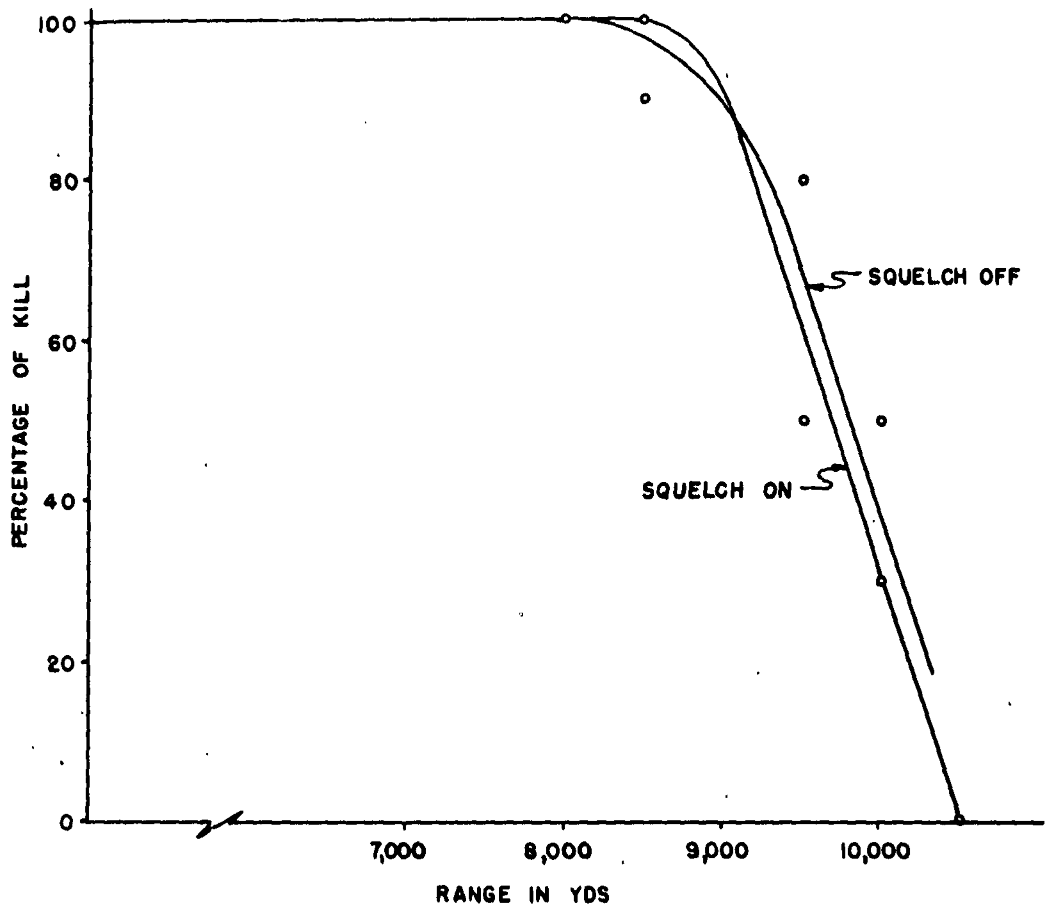


Fig. 9. Effect of squelch-circuit operation on kill

18. TEST 12, MAXIMUM EFFECTIVE RANGE, 90-DEGREE ASPECT, HIGH- AND LOW-ANGLE FIRE, OPTIMUM CONDITIONS

The purpose of test 12 was to determine the maximum range of the AN/MLQ-8(XL-2) at 90-degree aspect with optimum conditions* and to determine whether the antenna is more effective when mounted on a tripod or on a 1/4-ton truck.

A weapon range of 5,000 yards was used with charge 3 for high-angle fire and charge 4 for low-angle fire from a 105-mm howitzer. The jammer was positioned at 90-degree aspect and optimum conditions were used. The jammer was moved along the line of 90-degree aspect to increase or decrease the jamming range. The results of the test,

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* See appendix A for definition of optimum conditions.

as shown in fig. 10, indicate that the maximum jamming range against high-angle fire is 11,000 yards and against low-angle fire, 9,000 yards. Fig. 10 also shows that the antenna mounted on a 1/4-ton truck is more effective than the tripod-mounted antenna, particularly near the maximum kill point.

19. TEST 13. JAMMER EFFECTIVENESS AGAINST CVT FIRE, AVERAGE CONDITIONS

The purpose of test 13 was to determine the jammer effectiveness against CVT fire, average conditions.

The test employed only CVT fire,* both high angle and low angle, at aspects of 45 and 90 degrees. The T226E2/A fuze was fired from a 105-mm howitzer using a gun-to-target range of 5,000 yards with charge 4 for low-angle fire and charge 3 for high-angle fire.

The conditions of this test were

1. Aspect: 45 deg
2. Type fuze: CVT
3. Sweep rate: 2.0 sweeps/sec
4. Squelch circuit: on
5. Duty cycle: 1/5
6. Antenna polarization: 25 deg
7. Antenna elevation: 10 deg.

The results of the test under average conditions (see figs. 11 and 12) were

1. At 90-degree aspect:	
high-angle fire	7,200 yards
low-angle fire	4,800 yards
2. At 45-degree aspect:	
high-angle fire	4,500 yards
low-angle fire	3,800 yards

The results obtained at 90-degree aspect with optimum conditions were

Under optimum conditions:	
high-angle fire	11,000 yards
low-angle fire	9,000 yards

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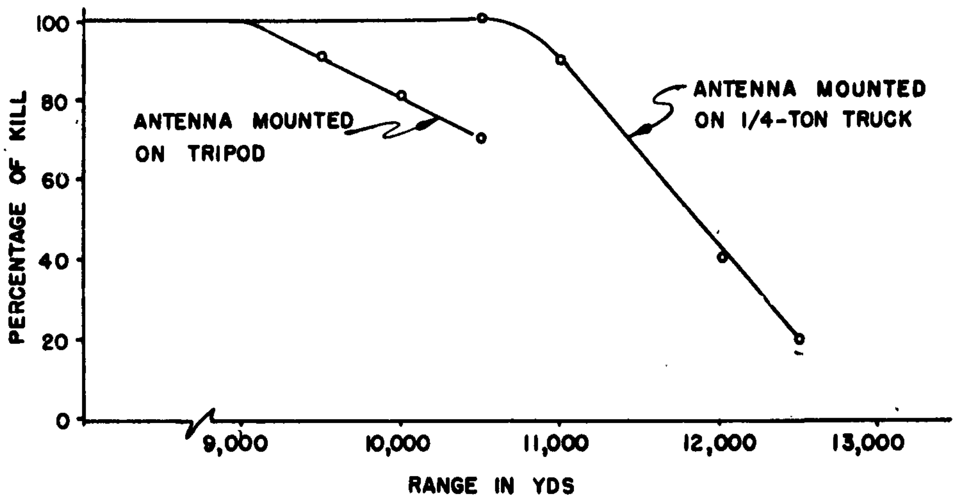
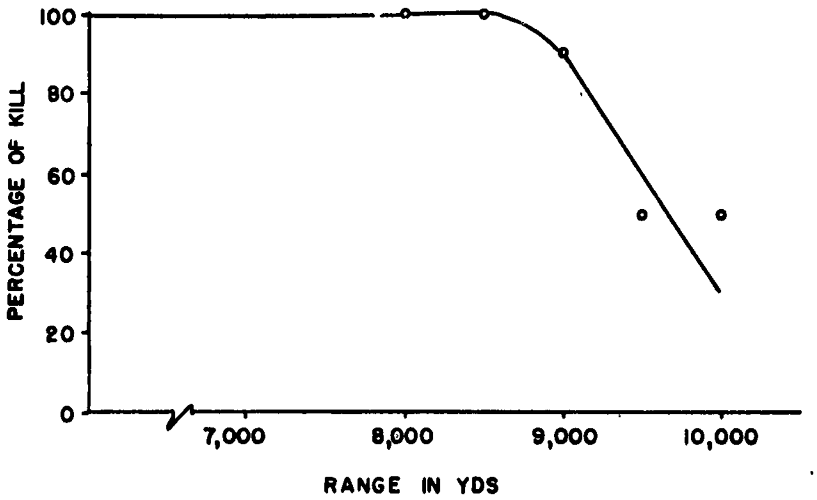
* See annex A for definition.

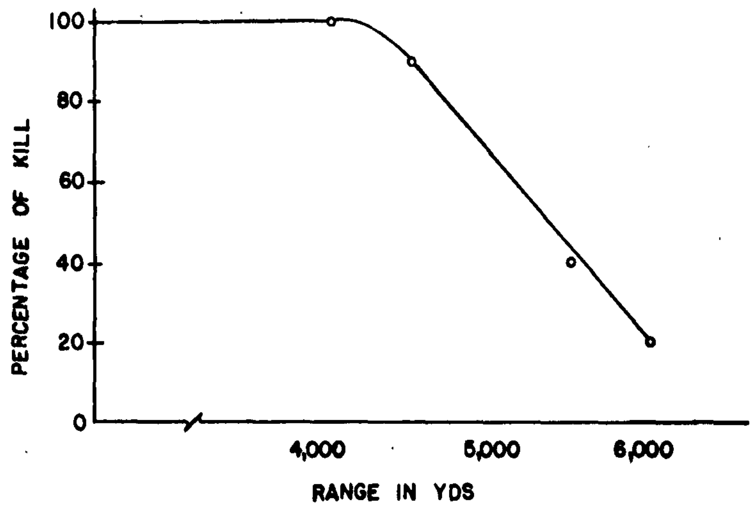


(A) HIGH-ANGLE FIRE

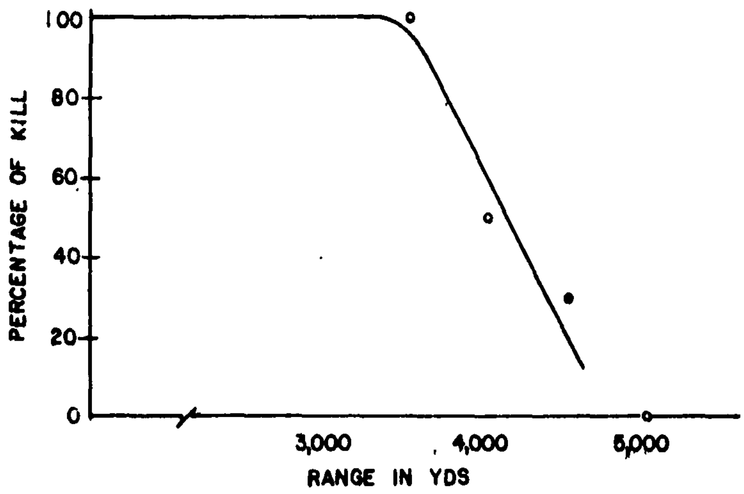


(B) LOW-ANGLE FIRE

Fig. 10. Maximum range at 90-degree aspect, optimum conditions, high- and low-angle fire

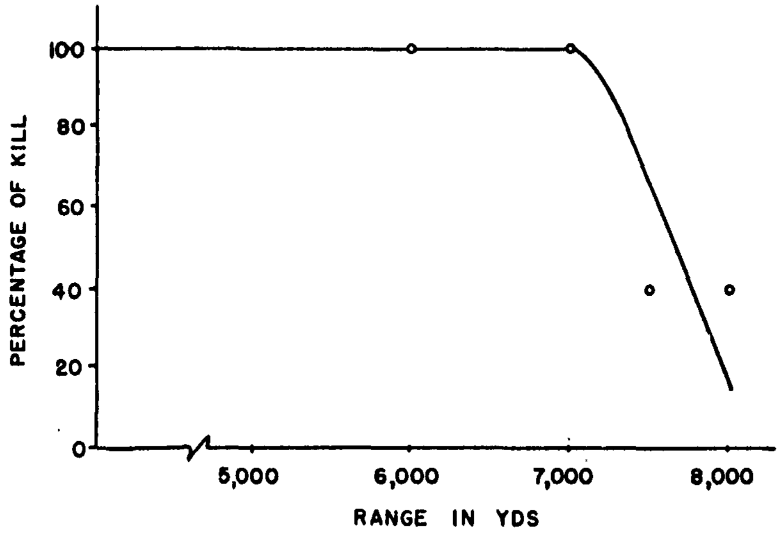


(A) HIGH-ANGLE FIRE

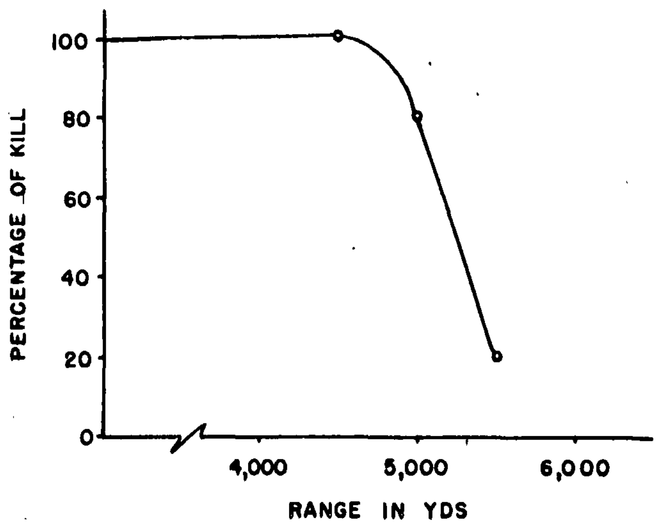


(B) LOW-ANGLE FIRE

Fig. 11. Effective range, 45-degree aspect, CVT action, average conditions



(A) HIGH ANGLE FIRE



(B) LOW ANGLE FIRE

Fig. 12. Effective range, 90-degree aspect, CVT action, average conditions

The preceding results demonstrates that changing from an optimum condition to an average condition reduces the effective range considerably; in the case of low-angle fire, a reduction of almost 50 percent is apparent. The effective ranges obtained with average conditions are much more significant than those obtained with optimum conditions, because of the probable use of this equipment in tactical situations.

20. TEST 14. JAMMER EFFECTIVENESS AGAINST CVT FIRE AT 0-DEGREE ASPECT, OPTIMUM AND AVERAGE CONDITIONS

The purpose of test 14 was to determine the jammer effectiveness against CVT fire, 0-degree aspect, optimum and average conditions.

This test was conducted with the aid of a bunker so that fire could be brought to within 200 yards of the jammer. Both high- and low-angle fire were used with two jamming conditions: optimum and average. The specific conditions were

a. Optimum Conditions

1. Duty cycle: 1/5
2. Sweep rate: 2.0 sweeps/sec
3. Squelch circuit: off
4. Antenna elevation and polarization: optimum

b. Average Conditions

1. Duty cycle: 1/5
2. Sweep rate: 2.0 sweeps/sec
3. Squelch circuit: on
4. Antenna polarization: 25 deg
5. Antenna elevation: 10 deg

All fuzes were armed three seconds before impact.

The results of this test appear in figs. 13 and 14. The minus figures on the abscissa indicate that the antenna was pointed opposite to the direction of fire and the target fired upon was behind the jammer. A serious lack of coverage and extremely short jamming ranges are evident, particularly if vertical or optimum polarization is used. It should also be noted that for the optimum case the jammer was considerably more effective against high-angle fire than against low-angle fire, while for the average case a serious lack of coverage occurred at 1,000 yards when high-angle fire was used. If fire were brought near the jammer's position, the chance of self-protection would be small if optimum settings were used. However, if average settings were used, the protection afforded at extremely short ranges would be greater than that afforded at slightly greater ranges of approximately

1,000 yards. In any case, the maximum effective range against 0-degree aspect fire is at best 2,000 yards. These results demonstrate that the present antenna used with the AN/MLQ-8(XL-2) is inadequate at short ranges against 0-degree aspect fire and will not function to provide self-protection for the jammer.

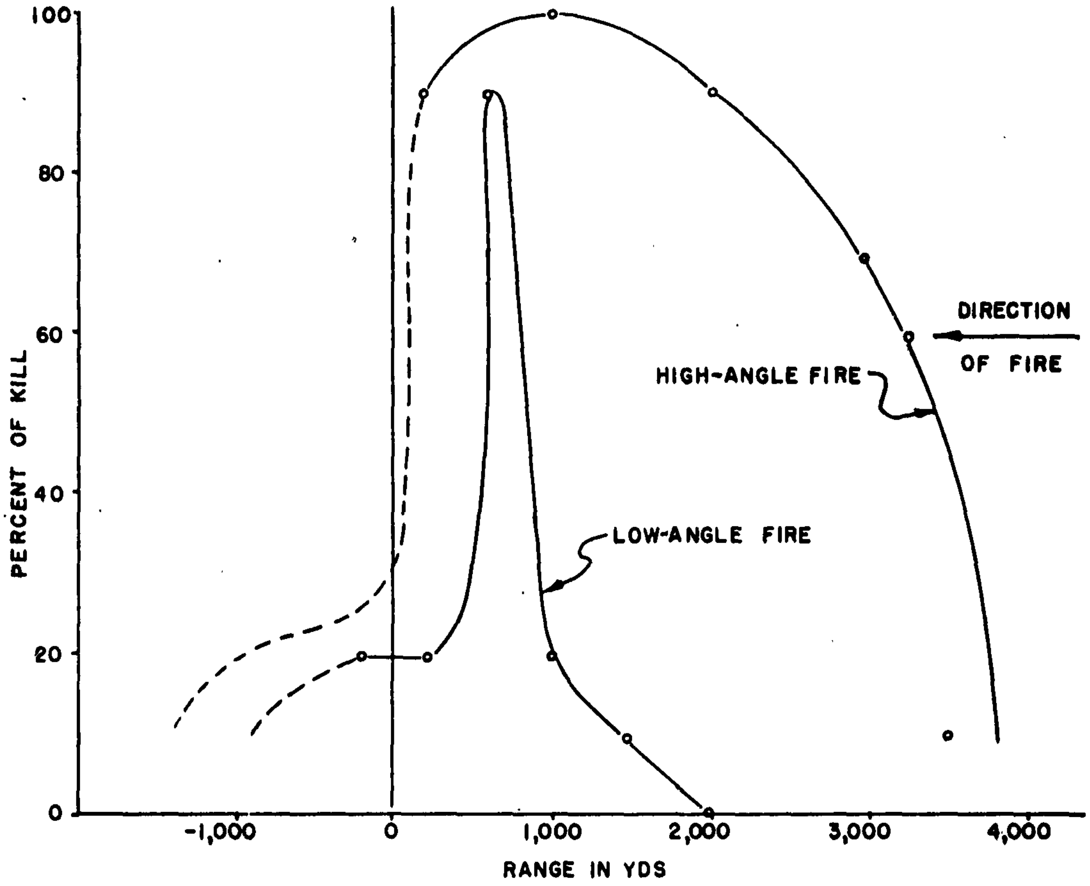


Fig. 13. Effective range at 0-degree aspect, CVT fire, optimum conditions

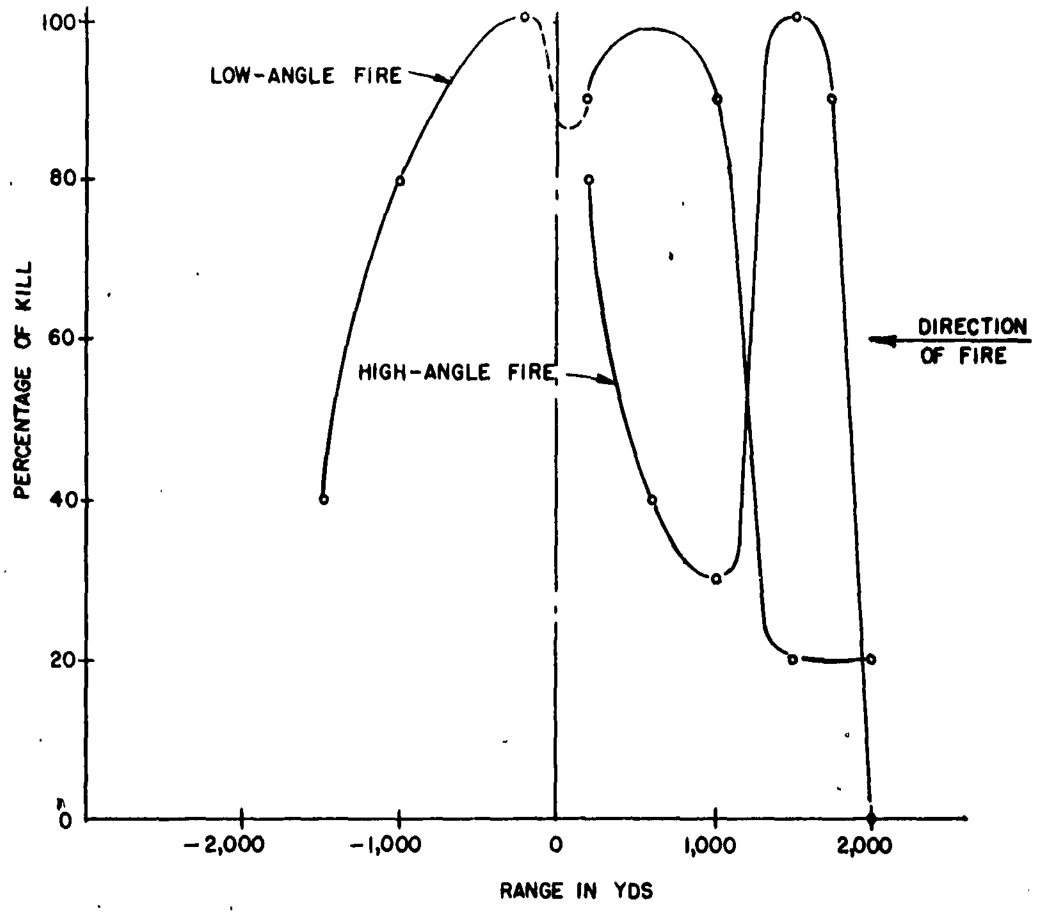


Fig. 14. Effective range at 0-degree aspect, CVT fire, average conditions

21. TEST 15. EFFECTIVE JAMMING RANGE AGAINST CVT 4.2-IN. MORTAR FIRE

The purpose of test 15 was to determine the effective jamming range against CVT 4.2-in. mortar fire.

The T226E2/A fuze which was used in the 105-mm howitzer test was also used in this test. In all the tests the jammer was sited so that its main lobe intersected the trajectory at 90 degrees at the point where the fuze became armed three seconds before impact.

The results shown in fig. 15 indicate the effectiveness with vertical, horizontal, and 45-degree polarization. It is apparent that 45-degree polarization yielded the best results. However, the reduction in range when horizontal or vertical polarization was used is not very great. The maximum effective range against the 4.2-in. mortar is, therefore, about 6,000 yards.

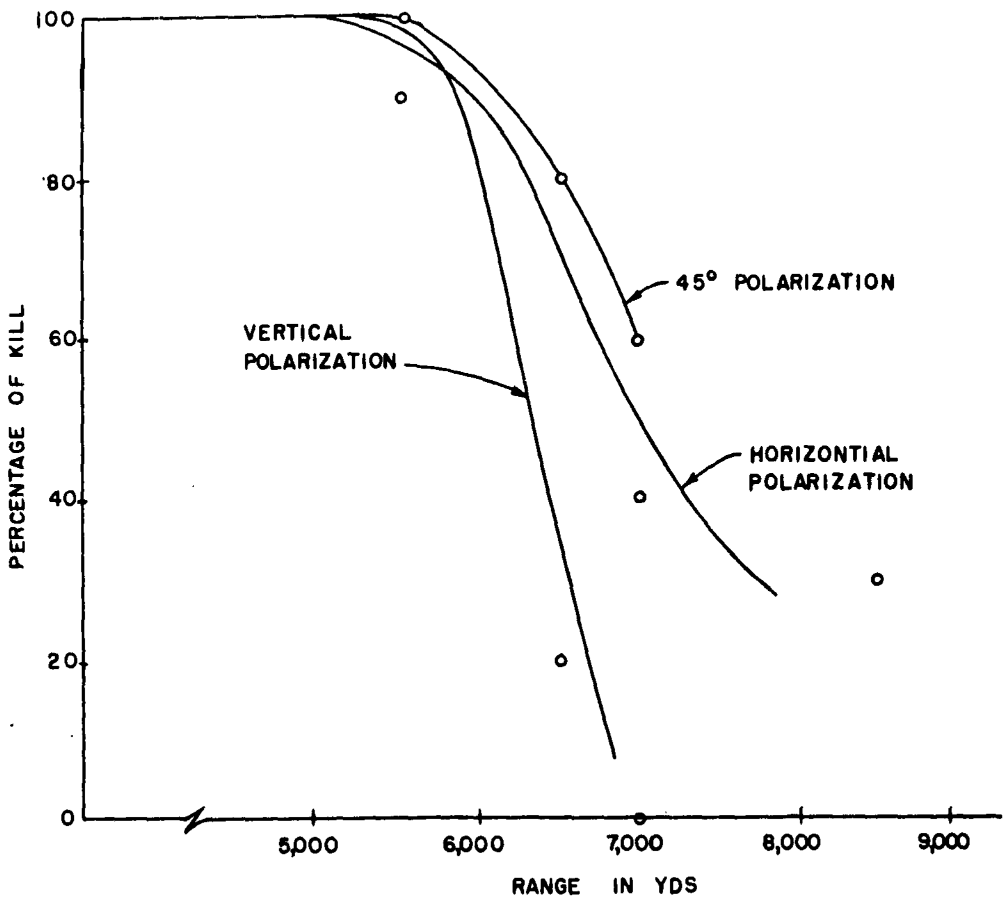


Fig. 15. Effective range against CVT 4.2-in. mortar fire

22. TEST 16. EFFECTIVENESS OF THE AN/MLQ-8(XL-2) AGAINST VT-FUZED 81-MM MORTAR PROJECTILES

The purpose of test 16 was to compare the effectiveness of the AN/MLQ-8(XL-2) against the VT-fuzed 81-mm mortar projectiles with results obtained in other tests. The fuzes for these projectiles, T178E3, operate in the band of 135-145 Mc/s. All parameters of this test were adjusted to be optimum. At no time was the effectiveness greater than 60 percent, even at ranges as short as 1,000 yards. It was noted, however, that a sweep rate of 1.25 sweeps/sec yielded the best results. This figure is consistent with that obtained in test 10, which determined optimum sweep rate against the 105-mm howitzer.

23. TEST 17. EFFECT OF LIMITED SATURATION ON EFFECTIVE RANGE

The purpose of test 17 was to determine the change in maximum effective range as the number of projectiles fired at one time was increased from one to four.

A gun-to-target range of 5,000 yards with charge 4, low-angle fire, was used. The antenna parameters were optimum, and a duty cycle of 1/5 with 2.0 sweeps/sec was used. The fuze was armed at the earliest safe time. The jammer was positioned at 90-degree aspect so that a kill of 90 percent was achieved against single rounds. Ten groups of two, three, and four projectiles were then fired and the changes in percentage of kill were noted. The only assumption in this test is that the slope of the curve of range vs percentage of kill remains constant regardless of the number of projectiles fired. The results appear in fig. 16. The solid curve is an actual range test against one projectile; whereas, the dotted curves represent the theoretical curves drawn through the point of percentage of kill established in this test for different numbers of projectiles.

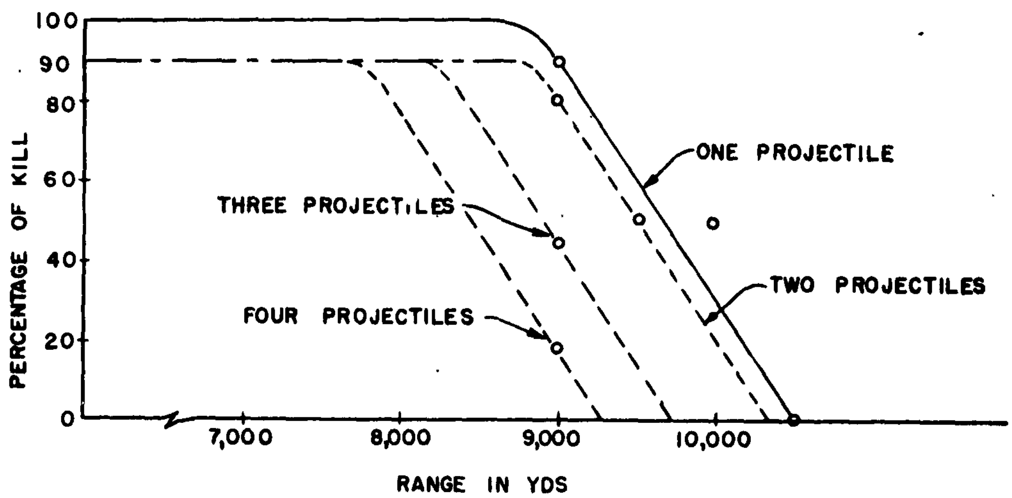


Fig. 16. Effect of limited saturation on effective range

As the number of projectiles fired simultaneously is increased, the maximum range decreases. In this case the range decreased from 9,000 yards to 7,800 yards as the number of projectiles was increased from one to four. Fig. 17 shows a group of fuzes predetonated in

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Fig. 17. Predetonation of VT fuzes in simultaneous flight

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simultaneous flight without power-sharing. Fig. 18 is a graph showing the deviation of the test results from the theoretical values.*

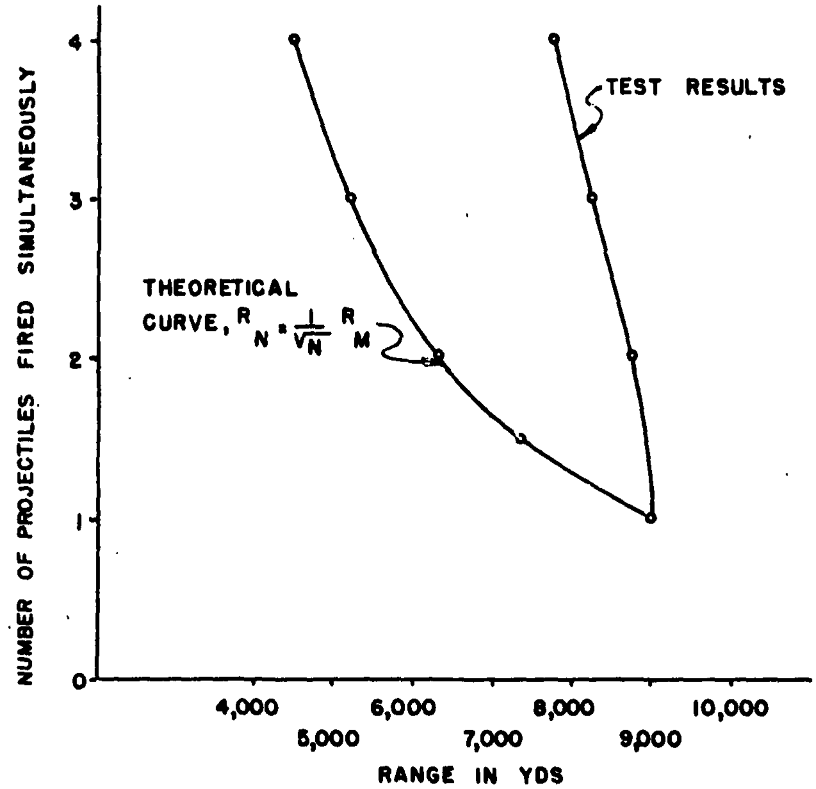

Fig. 18. Comparison of actual and theoretical results of multiple fire test

24. TEST 18, EFFECT ON FRIENDLY FIRE WITH JAMMER AT 0-DEGREE ASPECT BETWEEN OPPOSED GUNS

The purpose of test 18 in conjunction with test 19 was to determine how close friendly fire from 180-degree aspect can be brought to the jammer with the certainty that the fire will not be predetonated. The positions of the jammer and of friendly and enemy guns are shown in fig. 19. Each gun fired one round with the same time on target and both armed 3 seconds before impact. It was found that during high-angle

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*An EDG calculation indicates that R_n $\frac{R_m}{n}$ where n number of projectiles fired simultaneously, R_n maximum range obtained against n projectiles, and R_m maximum range against one projectile. This calculation is theoretically valid for the AN/MLQ-8(XL-2) only.

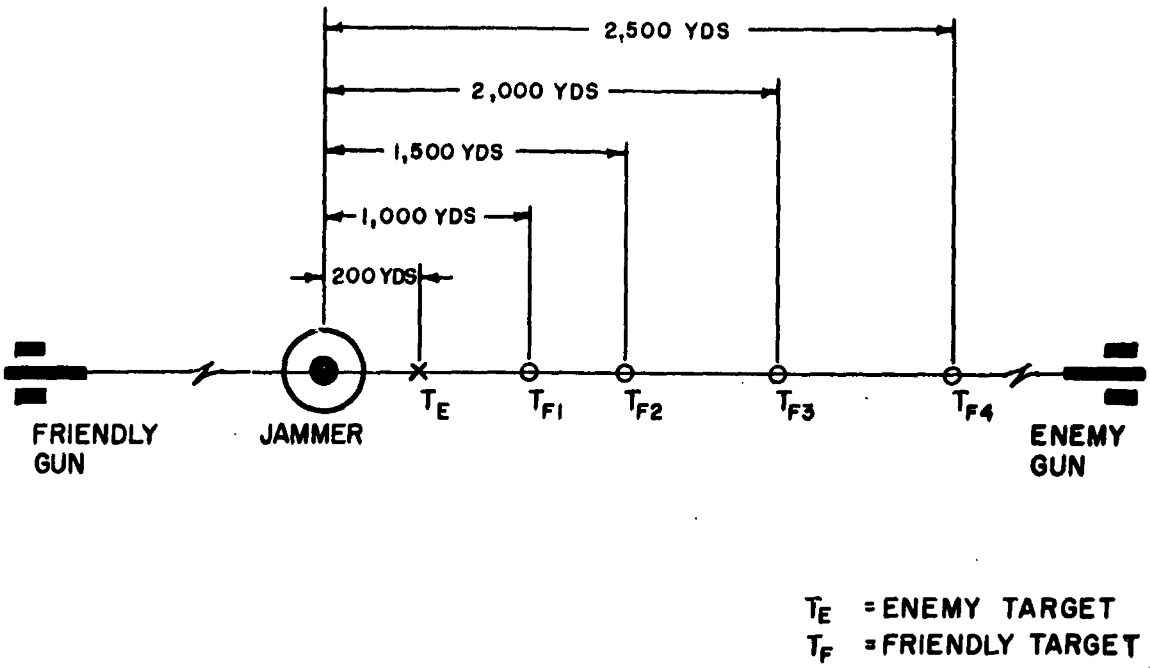

Fig. 19. Siting arrangement for test 18

fire both the enemy and friendly rounds were predetonated when the distance from the jammer to the friendly round was 2,500 yards. Five groups of 2 rounds each (one for each gun) were fired at this 2,500-yard range. During low-angle fire, with a range of 1,500 yards from the jammer to the friendly round, both the friendly and enemy rounds were predetonated. At a 2,000-yard jamming range all the enemy projectiles were predetonated, but none of the friendly rounds were jammed. Five groups were again fired at each of the ranges. It should be pointed out that the enemy target was not changed throughout this test. It is apparent that friendly fire can be directed at targets no closer than 2,000 yards from the jammer with the certainty that the fire will not be predetonated when the jammer is on a direct line between opposed guns. The use of the CVT feature of the T226E2/A fuze will, however, allow friendly fire to pass through the antenna pattern when this fire is directed at targets farther than 2,000 yards away from the jammer. The conditions of the test were

1. Polarization: vertical
2. Antenna elevation: 5 deg
3. Duty cycle: 1/5
4. Sweep rate: 2.0 sweeps/sec
5. Squelch circuit: on
6. Angle of fire: high and low.

25. TEST 19. EFFECT OF JAMMING ON FRIENDLY FIRE FROM OBLIQUE ASPECT

The purpose of test 19 was to determine how close friendly fire from other than 180-degree aspect can be brought to the jammer without predetonation. The relative positions of the jammer, guns, and targets appear in fig. 20. The enemy gun was firing on target 1 while the friendly gun fired upon targets 2, 3, and 4. All fuzes were armed 3 seconds before impact, and the weapons were fired so as to have all projectiles arrive at their targets at the same time. It was found that when the guns each fired one round, the closest the friendly fire could be brought to the jammer was target 4 or about 3,500 yards from the jammer. In this case, using low-angle fire, all of the enemy rounds were predetonated, but only one of the friendly rounds was predetonated. Ten rounds were fired from each gun. When two enemy and two friendly guns fired one round each (four rounds in the target area simultaneously), it was observed that the friendly fire could be brought to target 3 (3,000 yards from the jammer), but in this case a kill of 50 percent was obtained against the enemy fire and 10 percent against the friendly fire. In all cases the jamming parameters were average and the antenna was polarized for the enemy projectiles.

It can be concluded that friendly fire can be directed at targets no closer than 3,000 yards from the jammer under conditions of the test with not more than 10 percent of this friendly fire being predetonated. The use of the CVT feature of the T226E2/A fuze will allow this fire to pass through the antenna pattern when this fire is directed at targets farther than 3,000 yards from the jammer.

26. TEST 20. EFFECTS OF ADVERSE WEATHER ON JAMMING

The purpose of test 20 was to determine the effects of adverse weather on jamming.

The test was run on a rainy day with low-hanging clouds in order to compare results with those obtained on a warm, clear day.

The conditions of this test were as follows:

1. Aspect: 45 deg
2. Type fuze: CVT
3. Sweep rate: 2.0 sweeps/sec
4. Squelch circuit: on
5. Duty cycle: 1/5
6. Antenna polarization: 25 deg
7. Antenna elevation: 10 deg.

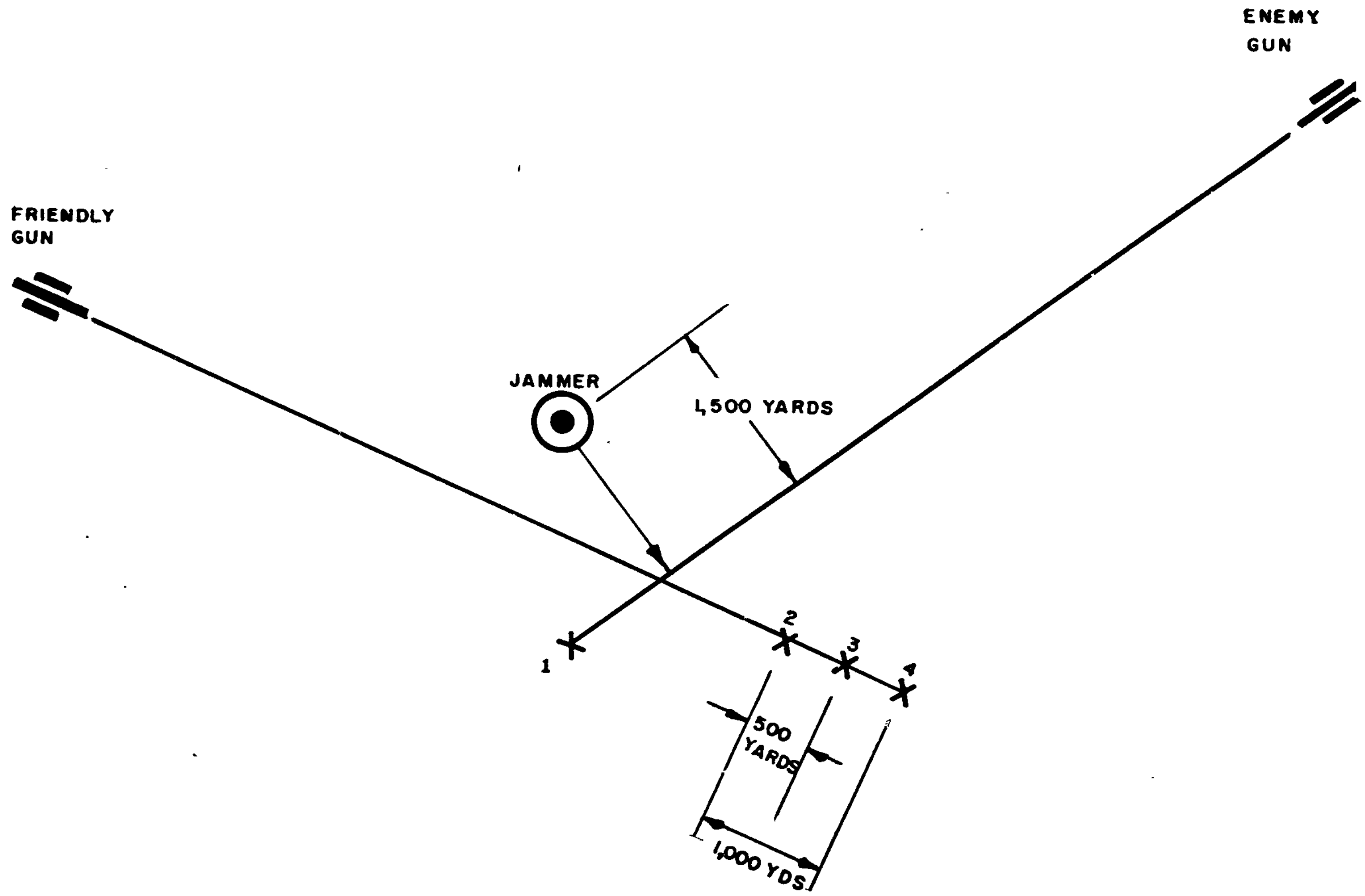

Fig. 20. Siting arrangement for test 19

The results of both tests are shown in fig. 21. It is evident that adverse weather conditions reduce the effective range from about 3,800 yards to about 3,500 yards for low-angle fire.

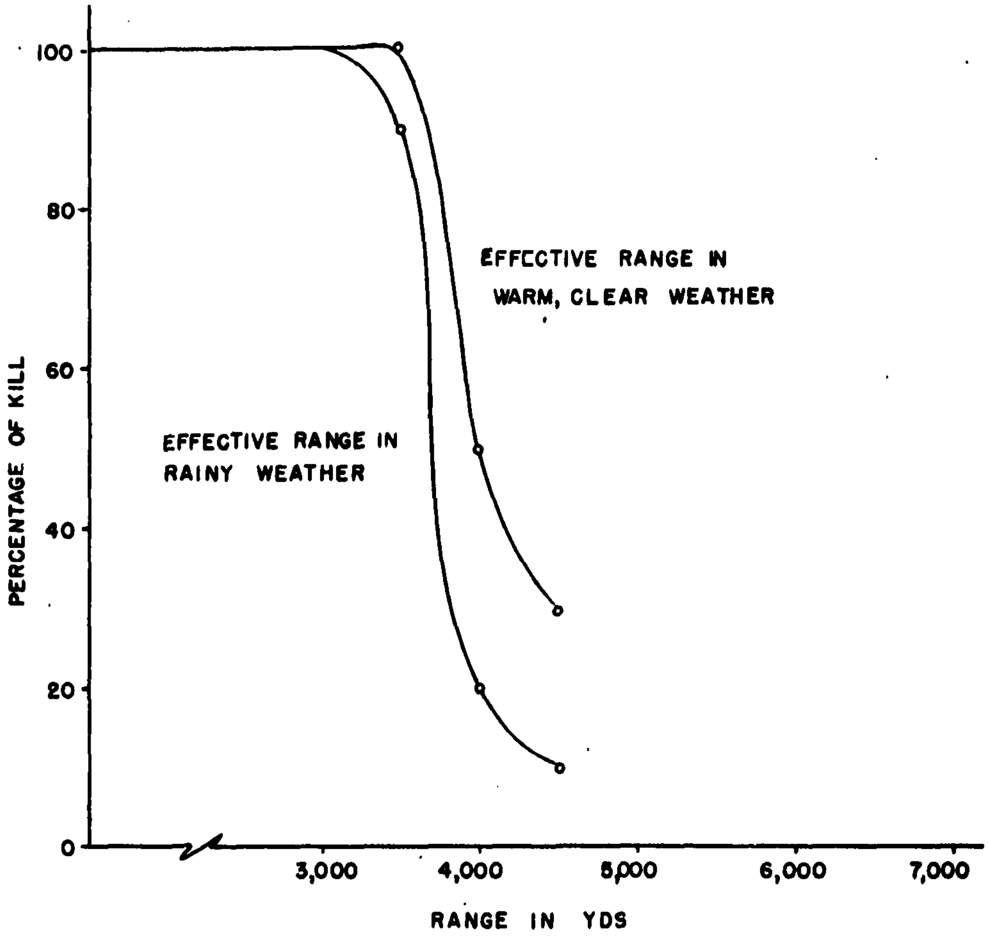

Fig. 21. Loss of range against low-angle fire in rainy weather

27. TEST 21. EFFECTS OF TERRAIN ON JAMMING

The purpose of test 21 was to determine the effect of uneven terrain or vegetation which obscures line-of-sight operation.

It was found that if the AN/MLQ-8(XL-2) was placed in position either in defilade or behind trees or shrubs to provide cover, the effectiveness was decreased in some cases as much as 100 percent. This, of course, would depend on the density of the trees or shrubs and on the amount of defilade. In general, if the equipment is sited on low ground out of sight of the target area with comparatively light foliage about 10-15 feet in height, the effectiveness will be reduced

approximately 50-60 percent if the jamming range is near the maximum effective range. If the jammer does not have line of sight with the fuze, it will be completely ineffective unless the exact conditions for beam diffraction exist. The possibility of such conditions existing for the desired frequency are so small that it can be said that the AN/MLQ-8(XL-2) is ineffective unless a line-of-sight condition can be provided.

28. TEST 22, EFFECT OF THE ENERGIZING CAM ON OPERATION

The purpose of test 22 was to determine to what extent the AN/MLQ-8(XL-2) could be disabled throughout its entire band and still prove effective against fuzes within a given band.

It was found that the set could be energized over any desired frequency band depending on the shape of the cam. Also, the change from full power output to zero output occurred in about 1 Mc/s during a sweep rate of 2.0 sweeps/sec. During a firing test it was noted that the energized band of the AN/MLQ-8(XL-2) was just as effective as when the set was sweeping its entire frequency band with the limitation that the AN/MLQ-8(XL-2) must be energized over the entire band of fuze frequency occurrence.

29. TEST 23, NUMBER OF SWEEPS REQUIRED FOR PREDETONATION

The purpose of test 23 was to determine the number of sweeps required for predetonation.

This test is a compilation of data gathered throughout the testing program of the AN/MLQ-8(XL-2). This was not a separate test but consisted, rather, of observations on the majority of the firing tests. The results presented are based on two periods of observation: the spring of 1956 and September of 1956.

The four tables which follow, nrs II to V, present observations on the number of sweeps required for predetonation of VT fuzes gathered from all the firing tests in which such data was taken.

Table II. Sweeps Required at Constant Range, Sweep Rate Variable, for Predetonation

Sweep rate (sweeps/sec)	Ratio of kill	Variation in sweeps required (nr)	Average nr of sweeps required (nr)
1.75	6/10	22-11	17.6
1.63	9/20	21-10	13.5
1.5	3/15	13-9	10.6
1.4	3/10	16-3	10.3
1.316	3/10	23-13	18.0
1.25	3/10	12-3	7.0
Constants of the test: equipment ser nr 2; fuzes armed 6 seconds after firing; squelch circuit inoperative; duty cycle 1/5; jamming range 12,500 yds; high-angle fire; 90-degree aspect; antenna elevation 8 degrees with horizontal polarization and mounted in a 1/4-ton truck; T226E2 fuze using 145 Mc/s			

Limited data are available for a jamming range of 5,500 yards with the same constants as those of Table II except a change in antenna elevation to 19.5 degrees. With a sweep rate of 1.6 sweeps/sec, of 10 fuzes fired, 7 were predetonated in from 3 to 5 sweeps each (average required, 3.7).

Table III. Sweeps Required for Predetonation at 45-Degree Aspect, Variable Range

Jamming range (yds)	Ratio of kill	Variation in sweeps (nr)	Sweeps required (average)
4,000	10/10	6-4	5.5
4,500	9/10	6-4	5.3
5,000	3/10	5	5
Constants of the test: equipment ser nr 3; T226E2/A CVT fuze using 165 Mc/s, arming 3 seconds before impact; high-angle fire with charge 3; sweep rate 2 sweeps/sec; squelch on; duty cycle 1/5; antenna mounted in a 1/4-ton truck with 25-degree polarization and 10-degree elevation; 45-degree aspect.			

Table IV contains data from a number of other firing tests; the table does not give ranges. The sweeps required for predetonation are differentiated from the two mountings of the antenna, in a 1/4-ton truck or on a tripod. Charge 3 represents high-angle fire, charge 4 represents low-angle, and charge 7 high velocity.

Table IV. Sweeps Required for Predetonation with Varied Parameters and Mounts

Arming (type)	Aspect (deg)	Antenna polarization	Average nr of sweeps before detonation				
			Charge 3		Charge 4		Charge 7
			(truck)	(tripod)	(truck)	(tripod)	(truck)
CVT	0	Vertical	3.96	4.20	4.00	4.00	--
CVT	0	Horizontal	4.13	--	--	--	--
CVT	45	Horizontal	3.43	3.90	4.31	4.66	--
CVT	90	Horizontal	4.34	3.76	4.43	4.00	--
NVT (9 sec)	90	Horizontal	6.93	7.89	--	--	--
NVT (6 sec)	90	Horizontal	--	--	6.36	4.52	5.45

Table V presents separate data on the use of charge 7 because more detail is available than in any other category. The percentage of kill is not given, but the number of shells fired at each range is given as an index of merit.

Table V. Sweeps Required for Predetonation at Various Ranges with Charge 7

Range (yds)	Rounds fired (nr)	Sweeps to predetonate (average)
2,700	5	4.4
4,200	4	5.5
4,200	4	4.5
4,800	1	6.0
4,800	3	6.3
4,800	2	6.0
4,800	8	7.1
4,800	3	4.3
4,800	2	4.5
4,800	6	4.5
5,000	4	9.7
5,000	5	5.0
5,000	5	7.0
5,000	4	5.0

Table V. Sweeps Required for Predetonation at Various Ranges with Charge 7 (cont)

Range (yds)	Rounds fired (nr)	Sweeps to predetonate (average)
5,900	3	4.3
5,900	10	4.8
5,900	10	4.9
5,900	8	4.7
5,900	6	5.7
5,900	8	5.1
5,900	8	6.1
5,900	4	5.7
5,900	3	5.3
5,900	2	7.5
5,900	3	6.7
5,900	8	4.7
5,900	3	4.0
Average	132	5.45

Constants of the test: NVT fuzes arming 6 seconds after firing; antenna polarization horizontal; 90-degree aspect; mounted in a 1/4-ton truck.

From the results it is evident that the AN/MLQ-8(XL-2) requires an excessive number of sweeps before a predetonation occurs, particularly if the fuze is not armed until 3 seconds before impact. Theoretically, if the fuze is armed 3 seconds before impact and the jammer is sweeping at 2 sweeps/sec, the fuze would predetonate quite close to the ground if 4 to 6 sweeps were required.

30. TEST 24. TWO JAMMERS IN DEFENSE OF AN AREA

The purpose of test 24 was to determine how well an area approximately 1,500 yards in diameter could be protected against VT-fuzed artillery fire by using two jammers. Fig. 22 shows the relative position of the jammers, guns, and target. One pair of jammers was sited at points A and D, and then at points B and C, with their antennas pointed in the directions indicated. The guns were placed at positions 1, 2, 3, and 4 with the target in the center of the area to be protected, which is indicated by the dotted circle. During the conduct of this test all weapons fired 1 round for each trial with the same time on target. The fuzes were armed either early (6 or 10 seconds before impact) or 3 seconds before impact. The parameters of the test were

1. Antenna polarization: 25 deg
2. Antenna elevation: 10 deg

3. Sweep rate: 2.0 sweeps/sec
4. Squelch circuit: on
5. Antenna mount: 1/4-ton truck
6. Duty cycle: 1/5

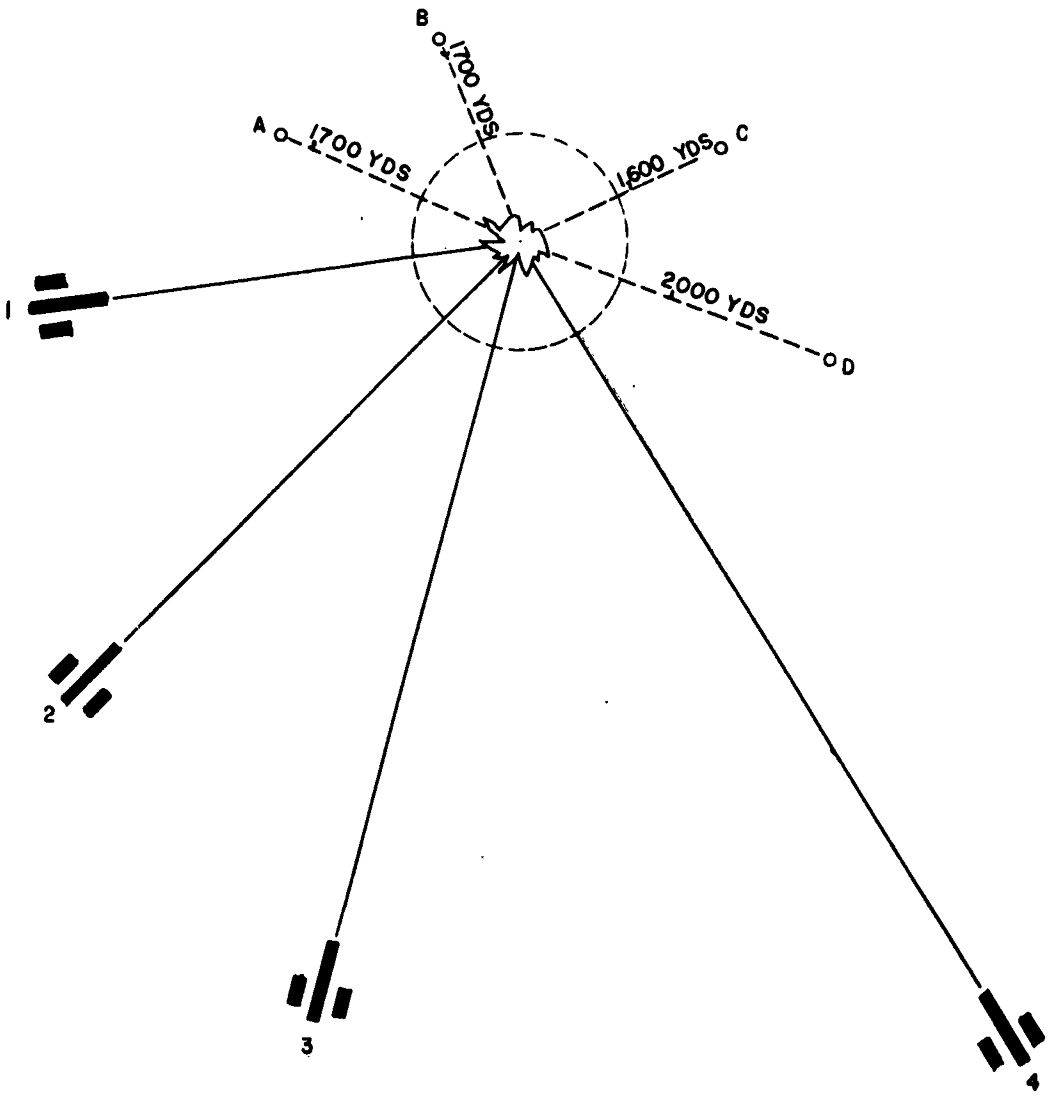

Fig. 22. Siting arrangements to test defense of an area

It was apparent from the results that two jammers could successfully protect an area of this size with the jammer positions as indicated in fig. 22, but slight variations in effectiveness were noted

as the positions were changed from A,D to B,C and as the angle of fire was shifted from low to high. The results were as follows:

Angle of fire	Arming time before impact (sec)	Jammer sites	Kill (%)
Low	6	A,D	94.4
Low	6	B,C	91.6
Low	3	B,C	79.2
High	10	B,C	82.1

It was noted that a reduction in power did not affect the fuzes which arm 6 and 10 seconds before impact but did affect the results against the fuzes arming 3 seconds before impact. A reduction of 1/3 in power output decreased the effectiveness from 75 to 25 percent.

The use of the CVT feature of the fuze evidently increases the potential of the artillery when there is a chance that VT fuzes may be jammed. A slight reduction of the jammer power reduces effectiveness only slightly except when the fuzes are armed 3 seconds before impact; then a change in effectiveness is apparent.

31. TEST 25. AREA OF PROTECTION

It may be expected that in actual combat there will be no opportunity to select an optimum setting for the various controls nor to adjust the antenna for different aspect angles or angles of fall of the enemy projectiles. Hence, a compromise setting of the antenna and controls must be used. This has been employed in several of the tests. A reading of the effective ranges shows that the shortest, 1,000 yards, is obtained at 0-degree aspect with low-angle CVT* fire and the use of the compromise conditions. The advantages of CVT fire to the artillery are such that it will unquestionably be used in preference to NVT or early-arming fire. Therefore, expectancy must be based on the figures for low-angle, CVT fire because they represent the worst circumstances, and the jammer may still be expected to combat shells at other angles. The ranges for low-angle fire are

0-degree aspect: 1,000 yards
45-degree aspect: 3,800 yards
90-degree aspect: 4,800 yards

*Fuzes armed 3 seconds before impact.

If the aspect is 0 degrees and the fire is CVT, the use of only one jammer reduces the protection to an area defined by the beam width of the antenna and a range of 1,000 yards with the possibility of a reduced effectiveness at ranges less than 200 yards. In view of the jammer's effectiveness at 90-degree aspect, this is an inefficient arrangement. Furthermore, shells traveling completely outside the beam width of the antenna could destroy the jammer.

If two AN/MLQ-8(XL-2) jammers are aimed directly at each other to protect each other and also to protect a common area against enemy fire arriving from a 180-degree sector (straight line MLR), the jammers must be 800 yards apart or more. The common area of protection is still very small, although if the sector is reduced to 90 degrees, the area may be twice as great; but with this siting each jammer is relatively safe from VT-fuzed fire. If the two jammers are sited to have their antenna axes intersect at 90 degrees, each can protect the other; the common area of protection against 180 degrees of enemy fire is approximately 4.5 sq mi.

Fig. 23 shows the coverage when considering the maximum range at 45-degree aspect. For this configuration the area of coverage is about 4.5 sq mi under the worst conditions. It is conceivable that the enemy fire would sometimes be at 90-degree aspect with respect to either jammer A or jammer B, in which case the area would be greater. The guns (1, 2, 3, and 4) and associated theoretical burst points indicate the theoretical coverage when the enemy is attempting to destroy jammer A with fire from the 180-degree sector in front of the protected area.

It should be remembered that the ranges used for this discussion are those obtained when countering one projectile at a time. It is more realistic to consider the case when more than one projectile is present to be jammed. This was the case in test 17. Considering the results of test 17, it is indicated that the jammers should be placed about 2,000 yards apart rather than at the 5,000 yards used in the previous discussion. This change will, of course, affect the area of protection provided by the two jammers. The same analysis would hold for the case of multiple projectile fire that was used for the case of a single projectile. In view of this change indicated by test 17, the area of protection is reduced from 4.5 sq mi to about 1.33 sq mi.

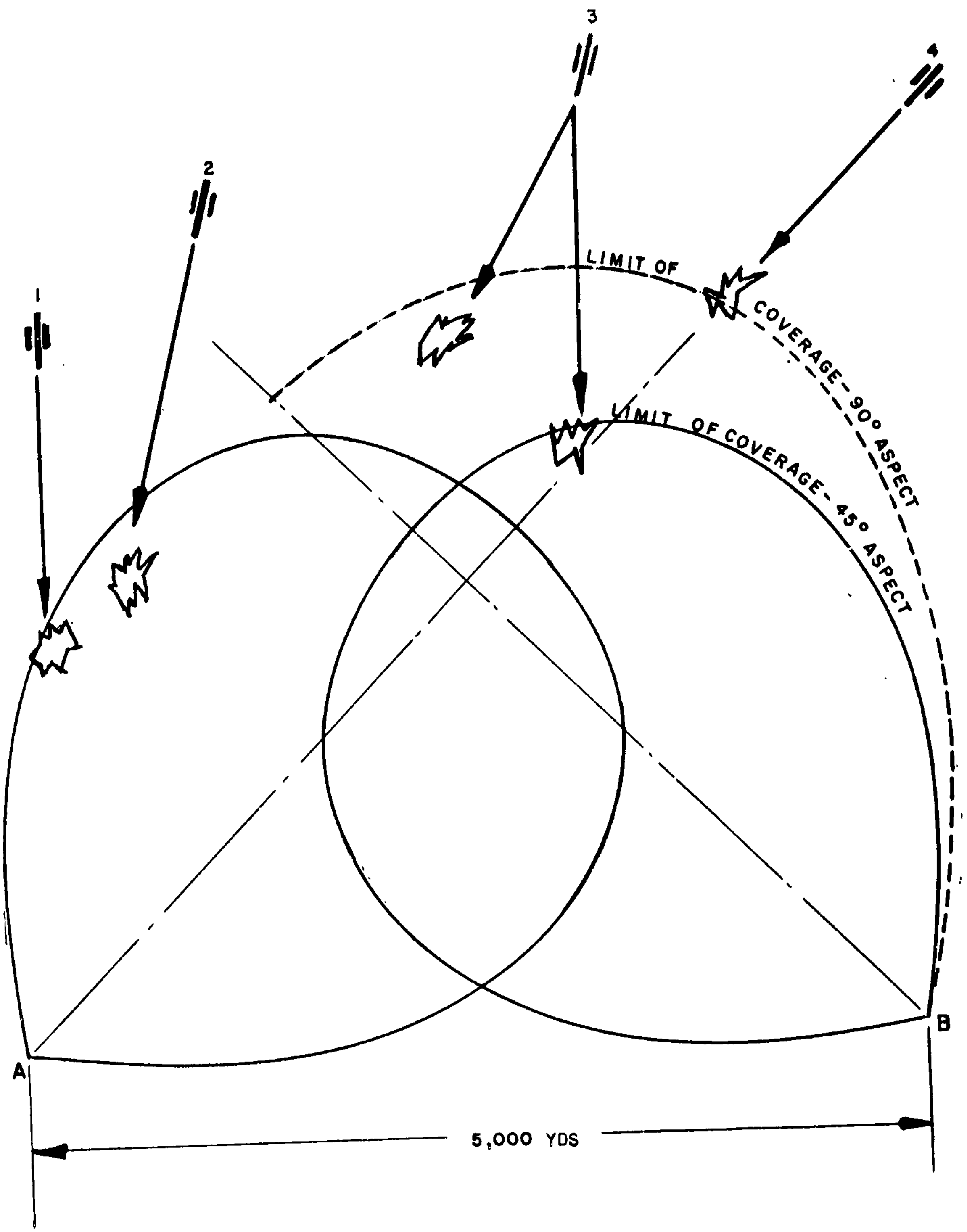

Fig. 23. Coverage at maximum range with 45-degree aspect

Section VII. Operational Requirements

32. TEST 26. LONG-TERM MAINTENANCE

The purpose of test 26 was to determine the probable need of repairs, the accessibility of the components, and the consumption of POL materials. Throughout the conduct of all tests utilizing the AN/MLQ-8(XL-2) equipment, no malfunctions were recorded.

A time study was made concerning the time required to remove certain units from the mounting brackets. Unit 3 was removed by pulling the cabinet toward the rear of the 1/4-ton truck. The first trial elapsed time was 50 seconds. A second trial reduced this time to 26 seconds. The removal of unit 5 proved to be more difficult due to the increased bulk and weight. This unit was removed by first stripping the 1/4-ton truck of the driver's seat and the frequency-limiting cam box. The unit was then pulled toward the front and out of the 1/4-ton truck. The first trial required 9 minutes 45 seconds while a second trial required 5 minutes 30 seconds.

An operating log of the PU-104 power unit (USA 01161690) was kept over the period 24 April to 25 June 1956. The data are as follows:

Total hours run:	132 hrs, 50 min
Gasoline consumed:	101 gal
Oil consumed:	None
Oil changes:	One required 4 qts
Number of operations recorded:	44
Gasoline consumption:	0.765 gal/hr

33. TEST 27. EVALUATION OF MAN-MACHINE COMPATIBILITY

The purpose of test 27 was to evaluate operating ease of the AN/MLQ-8(XL-2).

After preliminary, first-hand familiarization with the equipment, its operation in the field, the doctrine of its usage, and its capabilities, an Interview Record Form and an Observer's Record Form were devised (see appendix B) as instruments for obtaining information on equipment operating ease. The Interview Record Form was semistructured so as to insure systematic preplanned inquiry on the part of the interviewer of all aspects of equipment operation while at the same time permitting the interviewee conversational freedom. Comments were recorded directly on both types of forms.

Four operators who were considered to be experts in the operation of similar equipment but who had never operated the AN/MLQ-8(XL-2) were trained on the AN/MLQ-8(XL-2) during this test. They were then observed operating the equipment and interviewed. Five operators who were considered to be experts on the AN/MLQ-8(XL-2) were then each observed and interviewed. All nine operators were interviewed singly.

The purpose of testing inexpert before expert operators was to uncover fresh insights into possible shortcomings of the equipment about which the expert operators could later be questioned. It was believed that expert operators might have adjusted to certain deficiencies in the equipment over a long period working with it, that these adjustments might in fact be unnecessarily time-consuming and strain-producing, and that because of their adjustment to the deficiencies the operators might therefore neglect to mention them.

Methodology of the test consisted of the following procedures for the inexpert group. Two inexpert operators were present while an expert operator described the purpose of the test and procedures which would be followed. They then watched two expert operators set up, operate, and disassemble the AN/MLQ-8(XL-2) and heard a description of what was being done. Setting up began with the equipment in the 1/4-ton truck and trailer and included the erection of the antenna. Following this, the inexpert operators were asked if they had any questions and the questions were answered.

The subsequent process was conducted in each of four different environmental situations: (1) under normal daylight as in the demonstration situation, (2) with leather gloves to simulate cold weather operation and induce consequent awkward performance, (3) under instructions to work as rapidly as possible, and (4) while the 1/4-ton truck and trailer were in motion. Following the question and answer period two inexpert operators started the power unit, connected the power cables to the units, and set up the antenna. Then each in turn set the azimuth and elevation of the antenna to a fixed point. He then turned the equipment on and set the sweep rate. The operators ended their performance with disassembly of the equipment and placed it in the 1/4-ton truck and trailer as it was at the beginning of the test. Throughout all such tests under all four conditions, written comments were made on the Observer's Record Form; at the end of the tests interviews were conducted and opinions of operators were recorded on the Interview Record Form. Each man was interviewed separately. Finally, the process was repeated with the other pair of inexpert operators.

Methodology in testing the expert operators followed the same course as with the inexpert operators under normal, gloved, hasty, and mobile situations except that the demonstration, description of the process, and preoperation question period were eliminated. Five

expert operators were tested in this manner. In addition, tests with two of the five expert operators were run at night so that any aspect of the equipment that would be inadequate during night time operation could be ascertained.

The four inexpert and five expert operators were observed and interviewed over a period of three days. All of the subjects offered constructive comments on the AN/MLQ-8(XL-2) during the interviews. There was little discernible difference between the comments of the trained men and the comments of the untrained.

Following are the factors which the human engineers who interviewed and observed the operators believe restricted operating ease in the AN/MLQ-8(XL-2) unnecessarily as well as recommendations on how to lessen or eliminate these factors.

a. Canvas Size

The canvas stretched over the power unit shrinks when wet and makes it difficult in some places and impossible in others to lock the canvas into place. When manufacturers are fitting the canvas, this shrinkage should be considered for adequate protection of equipment and efficient assembly and disassembly.

b. Power Unit

The power unit did not have a self-starter. It had to be cranked before it would start. When the unit had not been in recent operation, cranking required from 2 to 9 minutes before the motor would start. The process involved using the choke, priming the motor, and cranking. Cranking had to be done in an awkward position. The motor was placed 1-1/2 feet forward from the rear of the trailer. Since there was no removable tail gate, the operator had to reach over the end, avoiding the reel which held the power cables, and then begin cranking. The leverage obtained in this position was not optimum. Two of the men who were slight in build climbed into the trailer, sat on the side, and cranked; again this position did not provide good leverage. In two cases after the power unit was shut off and an attempt made to start again, the motor flooded. It was necessary to wait until the gasoline evaporated before it could be started. Since time is critical in a tactical situation, a more reliable means of getting power quickly should be developed. Relocation of the engine to provide for better leverage in cranking or installation of a self-starter is needed. Modification of the gasoline engine design to obtain quick starting would prevent flooding.

c. Antenna Rack

The antenna is stored in a rack over the power unit in the trailer and must be extracted from the left side of the trailer. According to the expert operators the mount on the rear of the trailer is seldom used; the mount on the right rear of the 1/4-ton truck and the tripod for ground-mounting are used almost exclusively. The antenna had to be lifted out of the rack on the left side of the trailer and carried behind the trailer and to the rear of the 1/4-ton truck, a distance of approximately 20 feet. If the antenna were to be extracted from the right side of the trailer instead of from the left, an operator would have to walk less than 3 feet to bring the antenna to the mount on the rear of the 1/4-ton truck. If use of the trailer mount became necessary, the distance would still not be increased significantly if the face of the rack were on the right side. Changing the position of the face of the rack would decrease both the time needed to set up the antenna and the fatigue produced by carrying the antenna so far.

d. Antenna Elevation

To adjust the antenna for elevation, the operators used a lensatic compass (commonly called a "transit" and not a part of the AN/MLQ-8(XL-2) equipment) although there is an indicator on the antenna elbow that can be moved to change the elevation from the ground by means of a pole. When using the transit, it was customary for the operator to climb up to the antenna mast after it was erected, putting one foot on the roof of the trailer and one on the roof of the 1/4-ton truck, a precarious position not only because of the possibility of falling but also because the operator would present a target in a combat situation. It took approximately 3 minutes to adjust for elevation with the compass. Upon request one man used the pole instead of the transit to change the elevation; this took less than a minute. When asked why they did not use the indicator and pole, the men said it was not accurate. If the indicator is accurate enough for use in the field, the operating manual should so state. If it is not, the indicator end elbow should be redesigned.

e. Sweep Mechanism

After the equipment is turned on, the operator adjusts the sweep mechanism located in the right-hand side of unit 2. The sweep mechanism is set in a recess approximately 1-inch deep. To adjust it, a door to the recess must be opened and a lever raised or lowered until one of the gears achieves a desired speed. Thus, if instructions were to set the sweep mechanism at 1.8, the gear would have to complete the circle 18 times in 10 seconds. To time this, the men used a watch with a second hand. At the time of this test the importance of the difference in sweep rate in a tactical situation had not

been determined. If frequent changes in sweep rates are to be required, it may be desirable to have a tachometer built in or to calibrate the path along which the lever is moved accurately enough to set it in that fashion. At any rate, the present lever is hard to reach to make any adjustments. The door to the mechanism interferes with freedom of movement. If the door slid downward rather than opening to the left or if the lever were in the center of the recess rather than to the extreme left, then the parts to be adjusted would be more accessible.

f. Seating Arrangements

Six of the test subjects preferred to turn the passenger seat in the 1/4-ton truck around to face the equipment while operating. The seat was very unstable when thus reversed, and it slid around when the terrain was rough even though the 1/4-ton truck was moving very slowly. Two of the men, both inexpert, took the seat out of the 1/4-ton truck and squatted while operating the equipment. This would not normally be feasible if the 1/4-ton truck were in motion since there is no provision made for carrying a 1/4-ton truck seat in other than its usual place, and the squatting position is too uncomfortable for long periods of operation. One man, an expert operator, did not turn the seat around. He stated that after the equipment was turned on, there were few if any adjustments to make and it "wasn't worthwhile" to turn the seat around. Human engineer observers also felt that this would be satisfactory if there was assurance that in most tactical situations the sweep rate would not have to be adjusted to any great extent or if the sweep mechanism were so designed that the rate would be easily adjustable. If adjustments will be frequent or difficult or both and if the equipment will be operated while the 1/4-ton truck is in motion, it would be desirable to have the 1/4-ton truck seat lock in an optional backward position.

g. Radio Location

At present the radio is located at the rear on the left side of the 1/4-ton truck with its control surfaces facing outward. Operators have great difficulty manipulating radio controls from their seated position and usually have to get out of the 1/4-ton truck and perform such manipulation while standing. On the assumption that the radio will be of importance in tactical situations where a team leader is often controlling the movement of the 1/4-ton truck, the radio would be better placed where it could be operated while the 1/4-ton truck is in motion. Measurements of space available indicate that by redesigning the rack equipment, the transmitter-receiver can be repositioned to face forward with the power supply unit left in its present position. This repositioning would permit relatively easy access to radio controls by either the operator or the driver.

h. Lining of Antenna Rack

The rack in the trailer which holds the antenna has a felt-lined track. The felt did not lie flat and jammed the track when the antenna was being put away. This happened particularly when the men were working at high speed. Some better way of securing the felt to the track, or another type of equipment such as a rubber-cushioned metal track, would be preferable. If the present felt-lined track is retained, the ends of the antenna which dig up the felt should at least be rounded rather than having their present sharp edge.

i. Isolated Safety Factors

Several safety factors are unsatisfactory:

1. The power connectors on the power unit are not covered nor are there any warning signs near them to indicate the danger. A guard around them and a warning sign are needed.

2. Foam rubber on the side of the radio behind the driver's head could be increased from 3/4 inch to 1-1/2 inches for greater protection of the driver's head during movement over rough terrain. It would be well to provide similar protection on equipment behind the operator.

3. While putting the 1/4-ton truck in motion during one of these tests with the antenna mounted in a vertical position on the 1/4-ton truck, the shaft in the mast base housing broke causing the antenna to fall. Even if tactical theory prescribes that the 1/4-ton truck shall not be driven when the antenna is in operating position, nevertheless the 1/4-ton truck will in fact be thus driven at some time or other because of unusual circumstances, and injury to men and equipment may result from sudden breakage and falling of the mast.

j. Weight Load

Without exception, the men expressed the belief that the 1/4-ton truck and trailer were overloaded and that the equipment would get bogged down in sand or mud (the operators who had used the equipment in the field had experienced this).

k. Weather Conditions

The operators expressed concern about working in the 1/4-ton truck over long periods of time during a driving rain or cold. There were no side canvases forward of the equipment. Presumably they would

be furnished in a combat situation, but the operators still expressed doubt if they would be adequate in extreme cold. A standard auto-type heater installed in the 1/4-ton truck should aid in keeping the operators warm enough for effective cold-weather performance in all but the most severe climates.

l. Maintenance Ease

Two men in the group of expert operators were also maintenance men. They indicated that equipment components were difficult to remove from their racks and that this operation was unnecessarily time-consuming. For ease and speed in maintenance the method of holding the units in their racks should be improved. In connection with maintenance, these same men also advised having a box of spare parts with the equipment. Since it is probable that the 1/4-ton truck will operate far from supply sources in the field, much time could be saved by having spare parts readily available in the vehicle.

m. Operating with Gloves

Operators wearing gloves commented on the adjustments necessary on the sweep mechanism. The principal adjustment lever was too close to the left side of the recessed control area to be grasped with ease. See discussion of "Sweep Mechanism."

n. Operating at High Speed

Operators had trouble securing the antenna to the antenna mast during quick assembly because pins which fasten the two elements together were too short for easy and quick fastening. If pins were slightly longer this difficulty might be lessened considerably.

o. Operating at Night

Working at night created additional problems with the AN/MLQ-8(XL-2):

1. Two red lines on the dipole indicate the correct position of the antenna. These red lines could not be seen and the antenna was often placed incorrectly. To eliminate this, there should be a tactical way of ascertaining the correct position. A ridge, small enough to allow the antenna to pass over it yet large enough to be felt easily, could be added.

2. The operators had no way of reading the checkmeter, voltmeter, or ammeter. No trouble light was included with the equipment. The meters could have a soft light behind them so they could be read easily and quickly.

3. The power unit presents no major problems in the dark beyond those in daylight. There was, however, no way of knowing how much gasoline remained in the power-unit tanks.

4. Darkness intensified the problem of the sweep mechanism since the glow from the scope was scarcely sufficient to enable observation and timing of the moving gear, which is the key to adjustment. (Discussion of the part played by this gear in the adjustment process is found in the comment "Sweep Mechanism."

p. <u>Operating Manual</u>

Comprehensive operating instructions should be consolidated into a manual to simplify training as well as to increase the adequacy of the training. Disagreement and confusion were found among the expert operators. Beside exhibiting a lack of knowledge concerning the importance of the sweep rate differences and use of the indicator on the antenna for adjusting antenna elevation, the expert operators believed that it was necessary to wait 2 minutes before the high voltage switch was turned on. This was not true, but a 2-minute wait was necessary before the main power switch was turned off. These training problems could have been solved with the use of a comprehensive instruction manual.

Section VIII. Conclusions

34. CONCLUSIONS

It is concluded that

1. The electrical equipment is quite rugged, but the vehicle should have heavy duty springs on the rear axle. The antenna and mast must be stored in their respective positions prior to transit to avoid damage.

2. The equipment can be put into operation in 3-5 minutes and secured in 2-4 minutes depending on the mounting and location of the power unit.

3. A 12-percent decrease in line voltage results in a 60-percent decrease in power output.

4. No noise radiation is detectable when the squelch circuit is operative. However, with the squelch disabled, noise radiation was discernible up to 30,000 yards. At no time was 2d or 3rd harmonic radiation evident.

5. The AN/MLQ-8(XL-2) was found to be extremely difficult to locate by D/F equipment, and the signal is slightly less difficult to analyze. At best, a D/F reading within 10 to 15 degrees of the true bearing is all that could be obtained using the AN/TRD-10 with experienced operators. A signal analysis can be performed with fair accuracy in 1.5 to 3.5 minutes.

6. Aerial observation is difficult if reasonable concealment precautions are taken by the jammer crew.

7. When subject to night observation, the equipment is extremely difficult to locate. But since the power unit is quite noisy, aural detection may be the most successful type of observation at night.

8. Mutual interference between the AN/VRC-17 radio set and the AN/MLQ-8(XL-2) prevent the use of the intended communications channel during operation of the AN/MLQ-8(XL-2).

9. A duty cycle of 1/5 proved to be somewhat more effective than a duty cycle of 1/3.

10. A sweep rate of 2.0 sweeps/sec is best when countering low-angle fire employing the T226E2/A fuze.

11. The use of the squelch circuit has little or no adverse effect on the effectiveness of the jammer.

12. The maximum range of the jammer at 90-deg aspect with optimum conditions is 9,000 yards for low-angle fire and 11,000 yards for high-angle fire.

13. The AN/MLQ-8(XL-2) antenna mounted in a 1/4-ton truck yields better results than does the tripod-mounted antenna.

14. The maximum range against CVT fire under average conditions was

a. At 90-degree aspect:

low-angle fire	4,800 yards
high-angle fire	7,200 yards

b. At 45-degree aspect:

low-angle fire	3,800 yards
high-angle fire	4,500 yards

15. The maximum range at 0-degree aspect against CVT fire under average conditions was

low-angle fire	1,000 yards
high-angle fire	1,500 yards

16. The AN/MLQ-8(XL-2) does not perform well against 81-mm mortar projectiles; a kill of 60 percent at a jamming range of 1,000 yards was the best obtained.

17. The maximum range against the 4.2-in, mortar with the fuze armed 3 seconds before impact was about 6,000 yards. This was with 45-degree antenna polarization, which yielded the best results.

18. The effect of saturation and power sharing on the AN/MLQ-8(XL-2) reduced the percentage of kill from 90 percent

at 9,000 yards jamming range to 20 percent at 9,000 yards when the number of projectiles was increased from one to four.

19. In cases where both enemy and friendly VT-fuzed fire are present in the immediate area of the jammer and all fuzes are in the same frequency band, the friendly fire can be directed at targets no closer than 2,000 yards from the jammer if the friendly fire is at 180-degree aspect without predetonating friendly fire. If the aspect is approximately 45 degrees, the friendly fire can be directed at targets no closer than 3,000 yards without causing predetonation of more than 10 percent of the friendly fire. The use of the CVT feature of the T226E2/A fuze will allow friendly fire to pass through the antenna pattern when this fire is directed at targets farther than 2,000 or 3,000 yards from the jammer, depending on the aspect angles involved.

20. Adverse weather conditions, such as dense clouds, rain, and damp ground, reduce the effective range of the AN/MLQ-8(XL-2) at 45-degree aspect from 3,800 yards to 3,500 yards.

21. Placing the AN/MLQ-8(XL-2) in defilade or in moderate-to-heavy foliage may completely destroy its effectiveness. In general, moderate foliage and low ground with respect to the target area will cause a reduction in effectiveness of 50-60 percent. This equipment is ineffective without a line of sight to the fuze.

22. The AN/MLQ-8(XL-2) can be restricted in operation to any desired portion of its frequency range by selecting the properly shaped energizing cam.

23. The AN/MLQ-8(XL-2) requires, on the average, 5.45 sweeps across the fuze frequency before the fuze will be predetonated.

24. Two AN/MLQ-8(XL-2) jammers are capable of protecting an area of 1.33 sq mi against shell concentrations of four projectiles, all armed 3 seconds before impact. The theoretical area, based on the maximum range against one projectile, is 4.5 sq mi.

25. No high-echelon maintenance problems were observed during the test.

26. The gasoline consumption of the PU-104 power unit was found to be 0.765 gal/hr.

27. The gasoline engine of the power unit was found to be difficult to start. A provision for self-starting should be made.

28. The antenna storage rack can be more conveniently located and needs a differently designed track to replace the present one.

29. The passenger seat in the 1/4-ton truck should permit 180-degree reversal and locking in position so the operator may face the equipment.

30. Ease of operation of the sweep-rate mechanism could be improved through redesign.

31. Manufacturing dimensions of the canvas cover for the power unit need greater allowance for shrinkage.

32. The radio controls cannot be properly manipulated while the vehicle is in motion. Rearrangement of radio components is needed.

33. Design for ease of maintenance is unsatisfactory. The method of holding components in racks should be improved.

34. Fine adjustments to the equipment are difficult when operators are wearing gloves.

35. The use of tactile identifiers for night assembly of the antenna, and lighted equipment dials, where appropriate, would greatly assist operation in darkness.

36. A comprehensive manual of operating instructions is needed.

Annex A

Definitions

Aspect: The angle between the projection of the jammer axis on the horizontal and the projection of the projectile trajectory on the horizontal. When they are perpendicular, the aspect is 90 degrees. When the jammer antenna faces into the direction of fire, the aspect is 0 degree.

Average conditions: Those conditions that would probably be encountered in a tactical condition; such as 10-degree antenna elevation, 25-degree antenna polarization, 1/5 duty cycle, squelch on, optimum sweep rate for low-angle fire.

CVT fire: Fire in which the fuze is actively armed 3 seconds before impact (3BI). In actual practice the artillery team sets the timing on the fuze for the expected duration of flight in seconds, and the fuze actively arms 3.87 seconds (average) prior to the time indicated on the timing ring.

Duty Cycle: The ratio of the length of time of the transmit period to the time required for one cycle.

Elevation: The vertical angle at which the axis of the main lobe of the antenna is set.

Jammer axis: The projection on the horizontal of a line beginning at the jammer antenna and passing through the geometric center of the main lobe of the antenna radiation pattern.

Jammer range: The shortest horizontal distance between the jammer and the projectile trajectory.

Maximum effective range: The greatest range in yards at which a 90-percent kill is achieved against single VT-fuzed projectiles.

Optimum coupling: A condition of operation wherein the jammer antenna is aimed directly at a point in a known projectile trajectory and wherein the antenna polarization is adjusted to be the same as the "slant" of the projectile at that point.

Optimum jammer conditions: A condition of operation in which the coupling is optimum and the individual jammer parameters are those which produce the best results for the given situation. The fuze is armed at the earliest safe time.

Polarization: The angle measured from the horizontal toward the point of impact at which the E vector of the jammer antenna radiation is oriented.

Sweep rate: Number of times per second that the instantaneous bandwidth of the equipment is swept over the entire frequency range.

Annex B

Observer's and Interviewer's Record Forms

1. Observer's Record Form for tests of AN/MLQ-8(XL-2)
2. Interviewer's Record Form for tests of AN/MLQ-8(XL-2)

UNCLASSIFIED when not filled in

1. OBSERVER'S RECORD FORM FOR AN/MLQ-8(XL-2)

Observer ____________________ Date ___________________________

AN/MLQ-8(XL-2) serial nr _____ Interviewer ____________________

Antenna man being observed_____ Operator of equipment ___________

1. Was there any trouble setting up antenna?

2. Was there any trouble starting power unit in trailer?

3. Observations as to comfort, restriction of movement, awkward positions and movements, etc.

4. Did operator see that antenna cable was connected before turning "operate" and "transmit" switches?

5. Did generator noise seem bothersome? Yes ___ No ___

6. Did operator seem to experience difficulty in turning knobs or switch? Yes ___ No ___

7. Did the operator seem certain of his adjustments on the sweep generator? Yes ___ No ___

8. Observations in regard to:

   (a) Operating with gloves or mittens on:

(b) Operating in the dark:

(c) Operating in moving vehicle:

(d) Operating at maximum speed:

9. Miscellaneous observations:

10. Were there any equipment failures?

UNCLASSIFIED when not filled in

2. INTERVIEW RECORD FORM FOR AN/MLQ-8(XL-2)

Interviewer ____________________ Date ____________________________

Operator _______________________

Interviewer: Now we are ready to ask you some questions about your experience in operating the jammer. You can help us most by being completely frank in your replies. Also, we will welcome any suggestions which you have even though the suggestions do not seem to be connected with the questions.

1. Do you think the units are arranged the best way possible?
   Yes ___ No ___ Why?

2. Are you left handed? Yes ___ No ___

   a. Did you feel at a disadvantage in operating the equipment because of your (left) (right) handedness? Yes ___ No ___

   b. If so, how?

   c. Did you wish you could re-arrange the component units because of your (left) (right) handedness? Yes ___ No ___

   d. If so, what changes would you make?

3. How did wearing gloves affect your operation of the equipment?

4. What difficulties did you experience in operating the equipment in the dark?

5. What difficulties did you experience in operating the equipment while the 1/4-ton truck was in motion?

6. What difficulties did you experience in operating the equipment at high speed?

7. Did your seating arrangements interfere with your leg movements? Yes ___ No ___

   a. Was the seating arrangement uncomfortable? Yes ___ No ___

   b. Can you give me any suggestions or comments on the seating arrangement?

8. (For trained subjects only) Do you check to see that the antenna is connected before turning on the equipment?

   a. Do you think it is important to do so?

9. (For trained subjects only) When do you put the squelch on or off?

10. (For trained subjects only) What kind of errors are made in the setup of the equipment and what do you think causes them?

11. (For trained subjects only) Do you know the purpose of the check meter switch? Explain

    a. Do you use it each time you set up the equipment?

12. Did the generator noise bother you? Yes ___ No ___

13. What knob would you use to change the duty cycle from 1/3 to 1/5? When would you change it?

14. Do you like to operate the jammer? Why?

    a. What job do you like best? Least?

15. Do you think you will use the radio often?

16. Now we would like to have you offer your criticisms of the layout of the equipment, the placement of the knobs and dials, and anything else in the setup which affects your operation of the equipment. Tell me what you think is wrong with it, or how it may be changed.

    a. Layout of equipment

    b. Placement of knobs and dials

    c. Operating ehvironment

    Other suggestions (for trained only -- ask about maintenance)

(Note: thank respondent)